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CONTENTS

Diffusion coefficients of vitamins B_{12} and B_{12a}.
BRUNO JASELSKIS, JOSEPH F. FOSTER, and HARVEY DIEHL 1
Histology of the maize plant in relation to susceptibility to the European corn borer. . . . . MAX E. BELL 9
Effects of differential testosterone propionate levels on rat accessory gland activity. L.F. CAVAZOS and R.M. MELAMPY 19
Electrical conductance studies on an ion exchange resin.
R.P. PURI, FREDERICK R. DUKE, and JUNE LOMNES 25
A study of mixed gas adsorption on mercury.
ROBERT S. HANSEN and DORIS V. STAGE 33
Passage of cherry virus through Prunus root grafts.
O.F. HOBART, JR. 49
Full sib and parent offspring correlations in symmetrical random mating populations with the frequency of the more favorable allele the same at all loci. . . . . THEODORE W. HORNER 55
The components of variance in symmetrical random mating populations with the frequency of the more favorable allele the same at all loci. . . . . THEODORE W. HORNER 67
Measurements of the unsporulated oocysts of Eimeria acervulina, E. maxima, E. tenella, and E. mitis; coccidian parasites of the common fowl . . . . . E.R. BECKER, W.J. ZIMMERMANN, W.H. PATTILLO, and J.N. FARMER 79
Catalog of Eimeriidae in genera occurring in vertebrates and not requiring intermediate hosts. . . . . ELERY R. BECKER 85

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DIFFUSION COEFFICIENTS OF VITAMINS B_{12} AND B_{12a}

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Values for the diffusion coefficients of vitamins B_{12} and B_{12a} have been reported as 4.4×10^{-6} and 3.42×10^{-6} cm^2/sec., respectively (1). These values were obtained by the Stokes modification (2) of the Northup and Anson method (3). Molecular weight computations by the Stokes-Einstein (3) equation, using these values and the value 1.34 for the density of the crystal, give values of 550 and 1230, respectively, for B_{12} and B_{12a}. The value for B_{12} is less than half the molecular weight, 1370, calculated from the cobalt content of the dry material. There appeared also no reason why the method should have given a reasonable value for B_{12a} and failed for B_{12}. It seemed wise, therefore, to redetermine the diffusion coefficients by another method. Apparatus being available, the diffusion coefficients were determined by the free diffusion method (5, 6).

EXPERIMENTAL WORK

Materials. The vitamin B_{12} used was recrystallized from carbon dioxide free water and dried at room temperature over anhydrous magnesium perchlorate. A sample of this material, on further drying in vacuum at 80° for four hours, lost 12.35 per cent in weight, presumably all due to the loss of water.

Vitamin B_{12a} was prepared by the hydrogenation of B_{12} (7). In our preparation acetone was added up to 75 per cent before the filtration and oxidation step. Pure oxygen was used for oxidation. Carbon dioxide was excluded throughout the preparation. Crystals were obtained at room temperature in yields of about 70 per cent. The pH of an aqueous solution of this preparation was 9.1, in agreement with previous observations (8).

Attempts to crystallize B_{12a} from water without the addition of acetone failed to give crystalline material. In view of this, it was considered possible that acetone of crystallization was included in the crystalline B_{12a}. However, Mr. J. L. Ellingboe, in our laboratory, showed quantitatively by the 2,4-dinitrophenylhydrazine method (9, 10) that no acetone was present.

Measurement of Diffusion Coefficients. Diffusion measurements were carried out in the standard 11 ml Klett electrophoresis cell. The conventional Philpot-Svenson cylindrical-lens optical system with diagonal slit was used for both observation and recording of the concentration gradients. The gradients were recorded on 35 mm film by means of a Leica camera equipped with a focal-plane shutter. Curves for analysis

were made by tracing the image under a projection enlarger at a magnification of approximately nine-fold. In tracing the patterns, great care was taken to follow the center portion of the gradient outline. The overall magnification factor, cell to projected image, was determined directly by photographing a glass plate with etched rulings placed in the position of the cell and measuring the spacings in the projected image under the same conditions as employed for patterns. Measurements were conducted at two temperatures, approximately 2° and 25°. Temperature regulation was within approximately 0.01° at each temperature.

Known amounts of crystalline vitamin were dissolved in the solvent, either 0.1 N potassium sulfate or 0.1 N potassium sulfate plus 0.005 M potassium cyanide, so that the final concentration was 0.3 to 0.4 per cent. In all cases the solutions and solvent were brought to the temperature of the thermostat prior to filling the cell. The cell was filled in the conventional manner so that two boundaries were formed between the vitamin solution (below) and solvent of identical composition (above). After equilibration, the boundaries were made by opening the cell and moving to the approximate center of the cell using very slow (2.1 cm/hr) compensation by withdrawing electrolyte from the appropriate side by a synchronous motor-driven syringe compensator. The cell was then carefully closed for the duration of the runs which extended up to several days. In general, both boundaries were recorded and analyzed at intervals of 10 hours to three days. Calculations were made by the maximum height area method assuming monodisperse system (6).

The apparent diffusion coefficients of B_{12} at 25° in 0.1 N potassium sulfate, curve C, Fig. 1, decreased with increasing time and approached the value of B_{12a}. In view of this, a similar run was repeated with potassium cyanide added to the solution; the diffusion coefficient then decreased with time in a normal manner, Curve D, Fig. 1.

Measurement of Apparent Specific Volumes. The apparent specific volumes of B_{12} and B_{12a} were determined by the pycnometric method, the vessels being brought to temperature in a bath at 25.00 ± 0.01° and weighed against tares in a room of constant humidity thermostated at 25°. The concentrations were measured by colorimetric cobalt determinations on aliquots fumed with perchloric acid. The results are shown in Table II.

RESULTS AND DISCUSSION

The data obtained for B_{12} are plotted in Fig. 1, those for B_{12a} in Fig. 2. By extrapolation to infinite time, values were obtained for the diffusion coefficients. The estimated maximum error is between 6 and 10 per cent. Diffusion coefficients at different temperatures were calculated by the relation (5).

$$D_{25} = D_2 \left(\frac{298}{275}\right)\left(\frac{\eta_2}{\eta_{25}}\right)$$

the viscosity of water being used. The results of the measurements are shown in Table I.

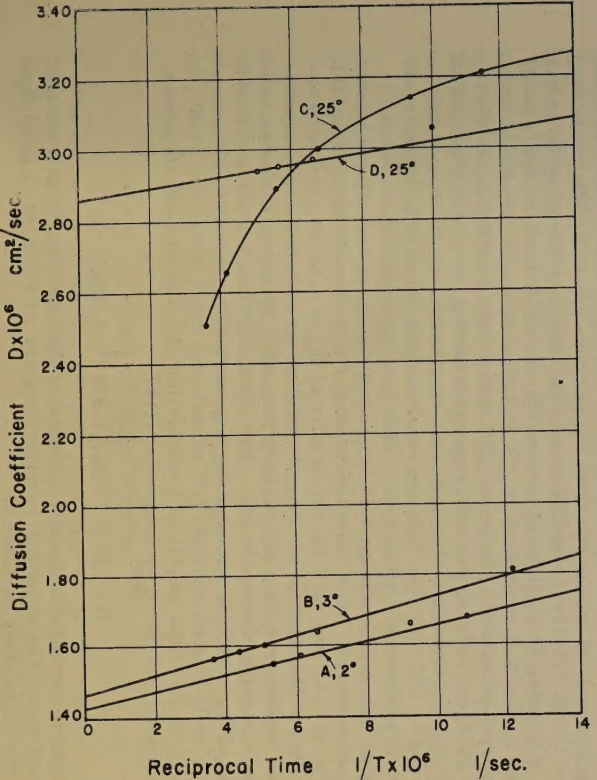

Fig. 1. Apparent diffusion coefficient of vitamin B_{12} as a function of time.

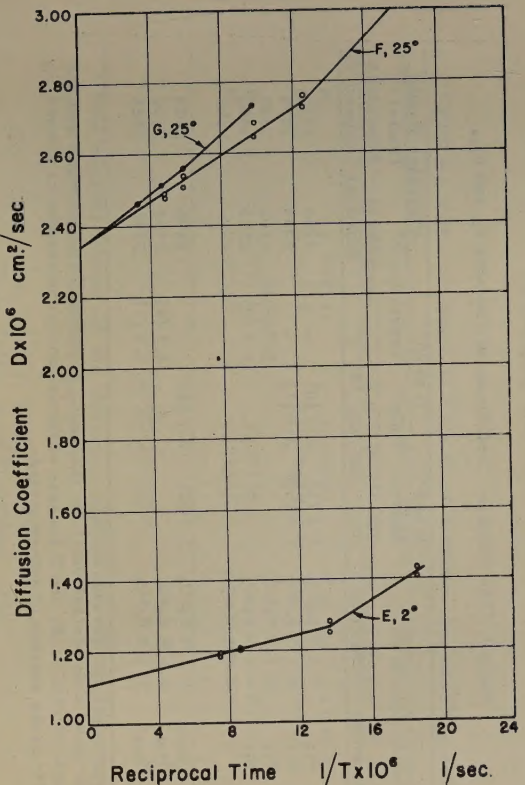

Fig. 2. Apparent diffusion coefficient of vitamin B_{12a} as a function of time.

Table I. The Diffusion Coefficients of Vitamins B_{12} and B_{12a}

Run No.	Material	Solution	D at 2° Exper.	D at 25° Calc.	D at 25° Exper.	Molecular Weight (Stokes-Einstein)	Molecular Weight (Stokes-Einstein-Longsworth)
			$cm^2/sec\ 10^6$				
A	B_{12}	0.1 N K_2SO_4	1.4 (3)	2.9 (0)	-	2244	1335
B	B_{12}	0.1 N K_2SO_4	1.4 (6)*	2.9 (7)	-	2088	1254
C	B_{12}	0.1 N K_2SO_4	-	-	2.7 (3)**	2703	1563
D	B_{12}	0.1 N K_2SO_4 0.005 M KCN	-	-	2.8 (7)	2316	1373
E	B_{12a}	0.1 N K_2SO_4	1.1 (0)	2.2 (4)	-	4496	2426
F	B_{12a}	0.1 N K_2SO_4	-	-	2.3 (4)	3934	2160
G	B_{12a}	0.1 N K_2SO_4	-	-	2.3 (7)	3792	2088

* Temperature for this run was 3°.

** This value is an average value for the run C; it should not be averaged with the results of runs A, B, and D because of the evident decomposition of vitamin B_{12} at 25° in the absence of excess cyanide.

It is evident from run C that B_{12} decomposes somewhat in water, probably with the liberation of cyanide and the formation of B_{12a}, the latter having a lower diffusion coefficient. Such a dissociation has been recognized previously (12). That this dissociation would be repressed by the presence of an excess of cyanide, as found in run D, was expected. In the presence of excess cyanide, B_{12} is converted to $B_{12}CN$ (containing a total of two cyanides) which is purple in color. Although a large excess of cyanide is required to convert B_{12} to $B_{12}CN$ (11), an appreciable amount of $B_{12}CN$ was present in the solution of run D for the solution was purplish in color. B_{12} and $B_{12}CN$ differ only slightly in weight (by 26 in 1370) and because the diffusion coefficient is inversely proportional to the molecular weight, the diffusion coefficients of the two would be expected to differ by less than the experimental error (7 to 10 per cent) in the measurement. Runs A, B, and D may therefore be averaged.

Using the values of the diffusion coefficients at 25°, the apparent molecular weights were calculated using the Stokes-Einstein equation. A value of 1.50 was used for the density of B_{12} in solution, and the value of 1.38 for the density of B_{12a} in solution as obtained from specific volume measurements. The value 8.93 x 10^{-3} dyne-cm/sec^2 was used for the viscosity of water at 25°. The value obtained for the molecular weight of B_{12}, 2085, is considerably higher than the value of 1370 calculated from the cobalt analysis (13) of material dried in vacuum at 80°.

Application of the empirical modification of the Stokes-Einstein equation recently developed by Longsworth (14).

$$D \times 10^6 = 33.06/(1.376V^{\frac{1}{3}} - 1.750)$$

leads to the average molecular weights of B_{12} and B_{12a}, 1380 and 2225, respectively. The apparent specific volumes of vitamins B_{12} and B_{12a} used are those given in Table II.

Table II. Apparent Specific Volume of Vitamins B_{12} and B_{12a}-25°.

Material	Density of sol.	Weight of B_{12} g per 5.076 ml	Apparent Specific volume ml per g
B_{12}	1.00031	0.04842	0.662
B_{12}	0.99978	0.04239	0.670
B_{12a}	0.99876	0.03104	0.727
B_{12a}	0.99840	0.02355	0.715

CONCLUSIONS

New measurements of the diffusion coefficients of vitamins B_{12} and B_{12a} by the free diffusion method give

B_{12} $2.9(1) \times 10^{-6}$ cm²/sec 25°
B_{12a} $2.3(3) \times 10^{-6}$ cm²/sec 25°

B_{12} decomposes slightly in water solution at room temperature. This decomposition is repressed by cyanide.

Values for the molecular weights of the two vitamins calculated from the diffusion coefficients indicate that B_{12a} is a dimer. Such dimerization must occur after dissolution. The dimeric character is also indicated by measurements of the sedimentation coefficient.

As with the earlier values for the diffusion coefficients, the new values lead to a molecular weight of B_{12a} almost twice that of B_{12}. However, the X-ray crystal pattern of B_{12a} is practically identical (15) with that of B_{12} (16) and the symmetry group into which both fall is such that the molecule cannot be other than a monomer. Any dimerization of B_{12a} must then occur after dissolution in water.

After the work being reported was completed, we learned that the dimerization of B_{12a} is caused by the union of B_{12a} with molecular oxygen. This dimer thus exists at low concentrations of B_{12} if sufficient oxygen is present.

Assuming that the maximum probable error in the measurement of diffusion coefficient is 10 per cent, the error in molecular weight calculated is not more than 30 per cent. This accuracy is sufficient to justify the conclusion that the molecule of B_{12a} dimerizes but that of B_{12} does not.

ACKNOWLEDGEMENT

The authors wish to express their appreciation of the support given them by The Squibb Institute for Medical Research for their work on vitamin B_{12}.

ADDENDUM

At our suggestion, Dr. Howard Schachman, of the Virus Laboratory, University of California, has now determined the sedimentation coefficients of vitamins B_{12} and B_{12a} in 0.1 M K_2SO_4. These measurements were made in the Spinco Untracentrifuge using the synthetic-boundary cell recently described by Schachman and coworkers (17). Schachman reports the following sedimentation coefficients (corrected to water at 20°C): for B_{12}, 0.50 Svedburg units; for B_{12a} 0.52 units. Each of these values is the average of three independent observations conducted over a concentration range of approximately 5 to 9 mg/cc. These values, together with our values of D and V, yield, upon substitution into the well-known Svedburg equation, molecular weights of 1420 and 2230 for B_{12} and B_{12a}, respectively. It is important to note that these results should be independent of any assumption as to shape or hydration, and should represent the unhydrated molecules. The agreement with the chemical molecular weight of B_{12} (1370) is very satisfactory and the contention that B_{12a} exists as a dimer seems substantially confirmed.

It should be noted that, strictly speaking, values of S and D which have been extrapolated to zero concentration should be used. It seems probable, however, that the concentration effects are relatively small for those small molecules.

We are indebted to Dr. Schachman for carrying out the sedimentation studies and for permitting our use of the data at this time.

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HISTOLOGY OF THE MAIZE PLANT IN RELATION TO SUSCEPTIBILITY TO THE EUROPEAN CORN BORER [1]

Max E. Bell[2,3]

The invasion of the midwestern corn belt by the European corn borer has greatly increased the economic loss due to this pest, and has accelerated research on control measures. The use of insecticides and the development of resistant lines have been the principal means of minimizing losses. An understanding of the basis for resistance often lags behind practical and effective control measures. This has been the case in the corn borer problem. It has been observed that different parts of the maize plant differ in susceptibility to attack, and that resistance changes during the growth of the plant. Severe larval infestation becomes evident after the plant has attained a minimum height (Beck and Lilly, 1949). These field observations suggest that anatomical changes during the growth of the plant may be associated with susceptibility. A study of these changes, as well as anatomical comparisons of varieties of maize, may provide basic information on some aspects of relative resistance to the corn borer.

MATERIALS AND METHODS

The lines of maize used in this study were selected to represent observable differences in susceptibility to corn borer attack. For the study of the susceptibility of small plants, the susceptible inbred line WF9 and the resistant inbred line L317 were used. Hatching egg masses were placed on plants as soon as the seedlings emerged from the soil, and at two-day intervals until anthesis. Leaf number, plant height, and stem-tip morphology were used as developmental markers.

Each sample for microscopic study consisted of portions of at least five plants. Selected parts of the plants were killed in Craf III and processed in a dioxane-normal butyl series for sectioning in paraffin (Sass, 1951).

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[2]Part of a doctoral dissertation submitted to the Graduate Faculty of the Department of Botany and Plant Pathology at Iowa State College. The author wishes to express sincere appreciation to Dr. John E.Sass for his guidance during this study, to Dr. G.F. Sprague and Professor F.F. Dicke for many helpful suggestions, and to Dr. Tom Brindley who provided field facilities.

[3]Now Associate Professor of Botany, Northeast Missouri State Teachers College, Kirksville, Missouri.

EXPERIMENTAL RESULTS

The data were obtained from field plots in 1952 and 1953. On seedlings infested the first or third day after the plants emerged from the soil, larvae of the corn borer did not survive. In the 1952 plantings there was no larval feeding on the fifth day after the plants emerged, whereas, at a corresponding stage in 1953, there was some feeding on leaves of WF9, but none on L317. As the leaves elongated out of the moist whorl area, there was no evidence of further leaf feeding, and dissections failed to reveal any larvae.

On the seventh day after the plants emerged (1952), one day after the larvae hatched, limited feeding occurred on some of the plants of WF9, but none of the larvae survived. No feeding was evident on L317. On the eighth day after seedling emergence (1953) there was heavy infestation of the plants of WF9, and L317 had pin-hole type feeding on its leaves. After the leaves elongated out of the moist area it became evident that larvae had become established. At this time, most plants of line WF9 had six visible leaves and L317 had four to five leaves visible.

The two lines began to show larval survival on the ninth day after seedling emergence (1952). At this time WF9 had six visible leaves and an average extended leaf height of 26 cm, and L317 had four visible leaves and an average height of 16 cm. On the eleventh day, WF9 had an average of seven leaves and an average height of 32 cm, and L317 had five leaves and a height of 20 cm. WF9 showed characteristically large lesions of the susceptible type, and L317 had the resistant pin-hole type of feeding on the blade. The survival of larvae continued to be high after this time.

The relationship between larval survival and morphological development of the seeding were studied in inbred lines WF9 and L317. The initiation of foliage leaves of maize proceeds rapidly at the time of emergence of the coleoptile from the soil. The apical meristem is approximately at ground level for several days after emergence. Lateral roots originate at the upper level of the mesocotyl, and a tiller may be evident in the axil of the lowest leaf (Figs. 1, 2).

Two days after the seedlings of WF9 emerged in experimental plantings, four leaves were externally visible, ten leaves were evident microscopically, and a tiller with three leaf primordia was present. Plants of L317 were smaller and had only three emerged leaves, and eight microscopically evident leaves. The first lateral roots had not broken through the surface of the axis and no leaf-bearing tillers were present.

The short, dome-shaped apical meristem of maize continues to lay down foliage leaf primordia until the ultimate number is formed and the vegetative phase of the plant is terminated. The vegetative apex undergoes rapid elongation, which is the first indication that the shoot apex is entering the transition from the vegetative to the floral phase (Fig. 3) (Bonnett, 1953).

The time required for the termination of the vegetative phase did not vary much between the 1952 and 1953 plantings. When plants of WF9 (1953) were six days out of the ground and had five or six visible leaves, the apices were beginning to enter transition (Fig. 4). At this age, L317

had some apices which were in transition. On the ninth day, transition was evident in L317 (1952). L317 lagged behind WF9 in both years. On the eleventh day (1953) WF9 averaged seven visible leaves, and one apex of the sample of five had initiated the first floral bract, whereas L317 had five or six emerged leaves and the seedlings were definitely in transition.

At eleven days (1952) both lines were in transition. Line WF9 had seven emerged leaves and a height of 32 cm, and L317 had five emerged leaves and an extended leaf height of 20 cm. Both lines were definitely producing tassel branches by the fifteenth day. At this time L317 had seven visible leaves and an average extended leaf height of 37.5 cm. Line WF9 had nine emerged leaves and an average height of 55.7 cm (Fig. 5). During two growing seasons, seedlings of L317 and WF9 became capable of supporting larvae of the corn borer only after the plants had entered transition to the flowering phase.

THE STRUCTURE OF EPIDERMIS IN RELATION TO INVASION

The structure of the epidermis of maize has been studies as a possible factor in the relative resistance to borer attack. The upper epidermis has several types of cells, bulliform cells, spicules, cushion hairs, bicellular hairs, guard cells, silica cells and the fundamental type epidermal cells. The rows of stomates are separated by fundamental cells. The rows of bulliform cells have spicules on each side, and occasional large cushion hairs arise from the center of a bulliform group. The lower epidermis has only stomates and fundamental type cells, with scattered hairs in some varieties (Prat, 1948).

Larval feeding has been observed to progress from the leaf surface to the opposite epidermis before the hole becomes much enlarged laterally. The opposite epidermis is usually left intact, and if the pin-hole is examined before the leaf elongates out of the whorl, an epidermal "window" is evident. It is easy, therefore, to determine on which surface the feeding begins. Larvae can begin to feed on either surface of the leaf; however, most of the lesions begin on the upper surface Fig. 6). The difference between initial attack on the upper and lower surfaces is statistically significant at the one per cent level.

The bulliform cells are the locus of initial attack by the first instar larvae (Fig. 7). Approximately 95 per cent of the lesions observed involve the bulliform cells, which are usually in the center line of the lesions. Some lesions involve only bulliform cells, others extend laterally into adjacent tissues, which may become undermined before they are involved (Fig. 6). Many of the lesions, expecially in a susceptible line are too small to be readily seen with the naked eye. Microscopically visible lesions of the pin-hole type may encompass two or three rows of bulliform cells, and susceptible-type feeding by established larvae may involve more rows. Large lesions made by establishing larvae are sometimes limited by the major vascular bundles, and there are indications that even minor bundles may restrict feeding.

The outer walls of the bulliform cells are thicker than the inner and lateral walls. The cuticle is not clearly delimited from the outer wall;

therefore, accurate measurements of the respective thicknesses of cuticle and the cell walls are not possible by conventional micrometry. The phase microscope reveals that the cuticle is perceptibly thinner over the bulliform cells than over the other epidermal cells, but measurements with an eyepiece micrometer are not sufficiently accurate to determine statistical differences.

Stained sections of leaves show a striking contrast between the staining reactions of the bulliform cells and other epidermal cells. With a carefully differentiated safranin-fast green stain, the outer wall of a bulliform cell stains a bluish green, whereas, the walls of the other epidermal cells stain red. Lines that are resistant to leaf feeding have a reaction to the stain which is slightly different from susceptible lines with respect to color as well as intensity of the stain. The walls of the bulliform cells of the resistant lines retain more safranin than do those of the susceptible lines. These staining reactions are not readily measurable quantitatively with the available facilities and therefore the differences can not be evaluated at present.

The total thickness of the outer cell wall plus the cuticle varies among lines and among epidermal cells. In forty-two samples of resistant and susceptible lines collected from the moist area of the leaf whorl, the walls plus cuticle of the bulliform cells average somewhat less than the fundamental epidermal cell walls of the same leaves. The measurements were made on images projected on a screen at a tremendous magnification and the differences obtained were found to be significant at the one per cent level.

ABNORMALITIES ASSOCIATED WITH BORER ATTACK

Extensive plugging of both xylem and phloem by unidentified microorganisms was noted in the region of attack (Fig. 7). Vascular plugging may extend for several centimeters. Some old lesions have adjacent areas in which limited proliferation has occurred. The most striking proliferation was found in the midrib of a leaf (Fig. 8).

DISCUSSION

The transition from the vegetative to the flowering phase is a turning point in the infestibility of corn by the European corn borer, as manifested by the survival of larvae. In some lines, transition occurs earlier than has been suspected, which is correlated with the fact that small seedlings are known to be infestible in such lines. As new lines of corn are developed, the correlation between floral transition and survival of larvae should be determined during several growing seasons under diverse conditions.

The foregoing observations suggest the possibility that the morphological transition to flowering may be associated with chemical changes that promote survival of feeding larvae. The refined biochemical techniques for such study are available and should be used in furtherance of the present problem.

A clue to another aspect of resistance to leaf feeding was provided by evidence that the larvae feed from the upper surface and that the bulliform cells are the locus of attack. The walls of the bulliform cells of resistant and susceptible lines differ perceptibly in dimensions and staining reactions, and it is possible that comparison on a more precise quantitative basis would contribute to an understanding of resistance to leaf feeding.

SUMMARY

A study was made of the structural development of the maize seedling in relation to invasion and feeding by the European corn borer.

When the stem tips of seedlings are in the vegetative phase, the plants are not capable of supporting larvae. Larvae begin to survive eight to nine days after the plants emerge from the ground, when plants are on the threshold of transition from the vegetative to the flowering phase.

Larvae begin to feed almost entirely from the upper survace of leaves, and the bulliform cells are the loci of attack.

Dissimilar staining reactions of the walls of the bulliform cells of resistant and susceptible lines suggest chemical differences. The outer walls of the bulliform cells are thinner than that of the other epidermal cells.

Resistant lines have pin-hole lesions involving relatively few cells. The susceptible lines have larger lesions, in proportion to the degree of susceptibility and size of larvae. The position and shape of the rows of bulliform cells regulate the shape of the lesions.

Vascular elements near lesions were found to be plugged by unidentified microorganisms.

Areas adjacent to some old lesions show evidence of cell proliferation.

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Fig. 1. Median longitudinal section of maize seedling, inbred line WF9, one day after emergence from soil. 10 X.

Fig. 2. Median longitudinal section of seedling of inbred line L317, one day after emergence. 10 X.

Fig. 3. Vegetative apex of inbred L317, three days after emergence. 160X.

Fig. 4. Apex at beginning of transition to the flowering phase, inbred WF9, six days after emergence. 80X.

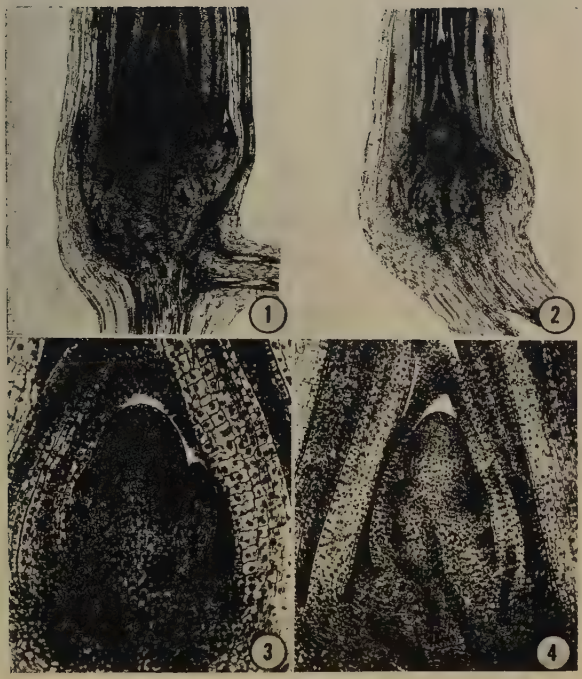
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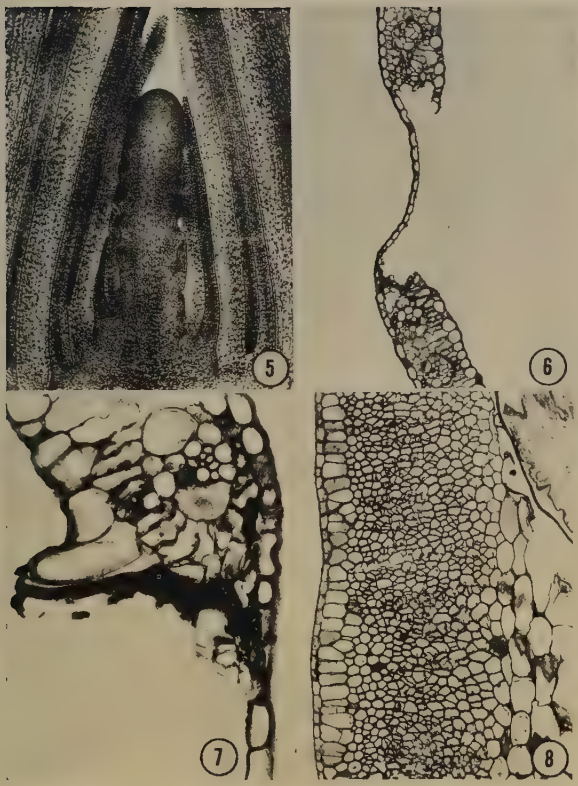
Fig. 5. Floral apex with developing tassel, inbred WF9, fifteen days after emergence. 48 X.

Fig. 6. Transverse section of leaf of inbred W22 from the moist area of the whorl, showing feeding from the upper surface, the lower epidermal window, and the undermining of the upper epidermis. 80 X.

Fig. 7. Transverse section of leaf of inbred W22, showing remnants of bulliform cells, and plugging of vascular element. 320 X.

Fig. 8. Section through midrib of unknown line, showing hypodermal proliferation near cavity made by corn borer larvae. 80 X.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EFFECTS OF DIFFERENTIAL TESTOSTERONE PROPIONATE LEVELS ON RAT ACCESSORY GLAND ACTIVITY[1]

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In a series of investigations, Moore and McGee (1), Moore and Gallagher (2), and Moore, Hughes, and Gallagher (3), have demonstrated the usefulness of the male accessory sex organs as objective indicators for studies on the physiological activity of the male sex hormone. Recently, through employment of biochemical and histochemical methods, others have studies the action of this hormone in a variety of problems concerned with the metabolism and structure of these organs (4, 5, 6, 7).

In the present investigation, observations were made on the effects of castration and androgen replacement on the weight and structure of rat epididymides. In addition, data were obtained on organ weights and amounts of secretion present in the male accessory glands. A histological study was also made on the distribution of lipids in those organs in intact, castrate, and hormone-treated castrate animals.

MATERIALS AND METHODS

A total of 110 sexually mature male rats of the Holtzman strain were used in this investigation. At the time of gonadectomy, the rats weighed 250-300 g. Immediately after castration, animal groups were injected with the following levels of testosterone propionate (T.P.)[2] in oil (0.05 ml): 0, 12.5, 25, 50, 100, 200, 400, and 500 μg. Injections were carried out daily for 20 days. Other animals used in this study were intact males and rats which had been gonadectomized for 120 days.

Each experimental group contained 10 animals. Seven of those were used to supply data on organ and secretion weights, whereas the remaining 3 were used to furnish tissues for histological studies. Organ dry weights were obtained by heating the tissues at 105° overnight in an electric oven. Bouin's and Zenker's fluids as well as Baker's (8) formaldehyde calcium were used as fixatives. Tissues to be used for lipid studies were embedded in gelatin. Frozen sections were cut at 10 μ and

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[2]Peranderen, Ciba Pharmaceutical Products, Inc., Summit, New Jersey.

stained with Sudan black B. Control slides were placed in an equal mixture of ethyl ether and absolute alcohol overnight prior to staining with Sudan black B.

RESULTS

The results of this investigation dealing with organ weight changes and the amounts of secretion present in the various accessory glands of the rat are summarized in Fig. 1 and Table I. These data are presented as means and their standard errors.

Table I. Effects of castration and different levels of testosterone propionate on amounts of secretions in accessory glands of the rat.

Group*	Dosage T.P. Daily/ 20 days	Seminal vesicles	Dorsal and ventral prostates	Coagulating glands
	μg	mg	mg	mg
1 Intact animal	0	761 ± 36**	405 ± 43**	81 ± 7**
2 20-day castrate	0	0	0	0
3 " "	12.5	12 ± 1	61 ± 9	6 ± 0.5
4 " "	25	107 ± 24	108 ± 13	12 ± 1
5 " "	50	313 ± 37	225 ± 17	33 ± 5
6 " "	100	541 ± 66	282 ± 64	48 ± 3
7 " "	200	1055 ± 39	548 ± 44	94 ± 7
8 " "	400	1451 ± 37	706 ± 34	131 ± 17
9 " "	500	1369 ± 85	624 ± 52	108 ± 8

* 7 animals per group.
** Mean and standard error.

A diffuse and granular sudanophilia was observed in the cytoplasm of the columnar epithelium of the epididymides of intact rats. This granular substance was localized in the Golgi zone of these cells. Sperm were noted in the tubules of the caudum epididymides. In these animals, the seminal vesicles were characterized by a diffuse cytoplasmic sudanophilia which was localized principally in the apical cytoplasm. Moreover, numerous nonreacting secretory granules, surrounded by clear unstained halos were visible. These observations on seminal vesicles are in agreement with earlier findings (9). Fine lipid droplets and a diffuse sudanophilia were noted in the apical region of the columnar epithelium of the dorsal and ventral prostates as well as the coagulating glands of intact animals. In addition, basal cytoplasmic lipid was visible in the prostates.

In the accessories studied, a marked epithelial regression occurred in the 20-day sesame oil-treated castrates and in the 120-day gonadectomized rats. In the epididymides, fine and large discrete lipid droplets were present in the cytoplasm of the atrophied columnar and basal cells. In the caput and corpus epididymides, large deposits of lipid were visible in the intertubular connective tissue and sperm were absent from the caudum epididymis. At these stages, the seminal vesicles demonstrated absence of secretory granules, the presence of a weak sudanophilia in the apical end of the cytoplasm, and a marked accumulation of discrete lipid granules and droplets in the basal region of the epithelium. Sudanophilic substances were present in the basal and perinuclear portions of the prostatic epithelium 20 days after castration. A diffuse sudanophilia, which included a few small granules, persisted in the apical part of the coagulating gland epithelium. Following 120 days castration, there appeared to be further aggregation of lipid in the atrophied epithelium of the prostates and coagulating glands.

Little, if any, increase in epididymal cell height occurred at the 12.5 μg dosage. The cytoplasm of the columnar epithelium demonstrated diffuse, fine, and large lipid droplets. Cytoplasmic lipid ringed the unstained nucleus of the basal cells of the caput epididymis, and was seen in the basal cell cytoplasm of the corpus and caudum epididymides. Large deposits of intertubular lipid were noted at this stage. Spermatozoa were present in the tubular lumina of the caudum epididymis. At this stage, only a slight epithelial reactivation occurred. Fine and large lipid droplets appeared at the basal region of the cuboidal epithelium. Although secretory granules were absent, the lipid accumulation was not as great in the seminal vesicles of untreated castrates.

Injection of 12.5 μg of hormone resulted in a slight reactivation of the secretory epithelium of the prostates and coagulating glands. However, these cells did not appear to have reached functional activity as yet. This stage was characterized by a diffuse sudanophilia at the apical ends of the epithelium of the prostate and coagulating glands, as well as a few discrete lipid droplets at the basal epithelial cytoplasm of the former organ.

At the 25 μg level, the epididymis still demonstrated the castration effects. A strong sudanophilia and numerous fine lipid granules were localized in the epithelial cytoplasm. Generally, the lipid reaction at this dosage was heavier than that noted for animals receiving 50 μg. Furthermore, some of the tubular epithelium contained larger quantities of lipid than other tubules, but at this stage the reaction was somewhat variable. Large amounts of lipid were observed in the intertubular connective tissue and spermatozoa were present in the caudum epididymis.

In seminal vesicles the sudanophilia at the 25 μg level was somewhat more diffuse than that in animals receiving 12.5 μg. Nevertheless, numerous fine granules were dispersed in the epithelial cytoplasm of rats receiving 25 μg of androgen. These lipid granules were localized principally in the basal region of the epithelium. Moreover, a few secretory granules were visible at this stage. Moore and Price (10) reported that secretion granules were visible in seminal vesicles of castrates following daily doses of somewhat less than 50 μg T.P.

Reactivation of the prostate had almost been completed in the animals

receiving 25 μg. Epithelial nuclei were large and cell heights had increased over the 12.5 μg level. There was a diffuse sudanophilia in the apical ends of the epithelial cytoplasm. In addition, numerous discrete, fine, lipid granules were dispersed in the apical cytoplasm as well as in the perinuclear and basal portions of the epithelium. At 25 μg T.P., a strong, but diffuse, sudanophilia was localized in the apical cytoplasm of coagulating gland epithelium. A few discrete, fine, lipid droplets were dispersed in the cytoplasm of these cells.

In general, the histology of the accessories examined at the 50 μg T.P. level and at the higher dosages employed, was similar to that of the intact animals.

DISCUSSION

The effects of castration and androgen replacement on the dry weight of the epididymides and secretion-free accessory glands are shown in Fig. 1. Twenty days following gonadectomy the decrease in weight of the epididymides was 67 per cent; the seminal vesicles 71 per cent; the dorsal and ventral prostates 69 per cent; and the coagulating glands 76 per cent. In castrates in which the accessory organs were allowed to regress 120 days, these organs showed the following decreases: 69, 84, 88, and 81 per cent, respectively. The epididymides and coagulating glands of these animals indicated little change beyond that observed in 20-day castrates. An increase in organ weight was found with increasing levels of testosterone propionate administered for a period of 20 days (Fig. 1). The epididymides attained maximum weight with approximately 150 μg of hormone. However, these organs did not reach the weight of those of intact animals. The smaller size of the epididymides in castrated animals is partially due to lack of sperm, and partially to loss of secretion and tissue (11).

The dorsal and ventral prostates of castrates receiving approximately 150 μg equaled those of intact animals, whereas the seminal vesicles and coagulating glands of animals injected with 100 μg compared favorably with those from animals producing testicular androgen (Fig. 1). However, it is of interest that following treatment with 50 μg T.P. or more, the histological distribution of lipids in the accessories studied was similar to that observed in intact animals. Therefore, less T.P. is required to achieve a histological pattern which is comparable to that of intacts than is needed to attain the dry gland weights of noncastrate animals. This is in agreement with Moore and Price (10) who reported that the dosage of male hormone necessary for maintenance of growth rates of seminal vesicles was approximately three times the amount required for maintenance of histological normality. The greatest change in lipid distribution occurred at the transitional levels which were activated by 12.5 and 25 μg T.P. daily for 20 days.

It was noted under the conditions of these experiments that the prostates and coagulating glands continued to develop with increasing amounts of hormone, whereas the seminal vesicles reached a maximum at a level of 400 μg . A daily hormone level of 500 μg caused a 104 per cent increase in dry weight of the epididymides above that of the 20-day cas-

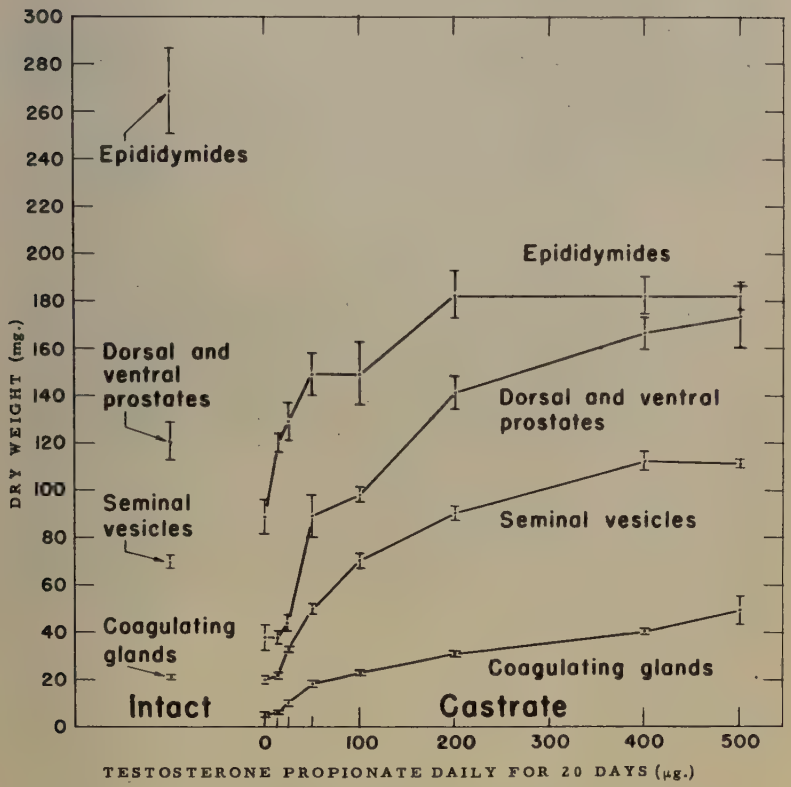

Fig. 1. Effects of castration and different levels of testosterone propionate on dry weight of epididymides and secretion-free dorsal and ventral prostates, seminal vesicles, and coagulating glands.

trates, whereas the seminal vesicles, prostates, and coagulating glands showed increases of 455, 355, and 880 per cent, respectively (Fig. 1). These data indicate the differential capacity of these accessory organs to respond to androgen.

Data presented in Table I relative to the amounts of secretion contained in male accessory glands suggest that the daily subcutaneous injection of approximately 150 μg of testosterone propionate in a mature castrate male maintained the seminal vesicles, dorsal and ventral prostates, and coagulating glands in a functional state similar to that found in intact males of the same age. The quantity of secretion present in the glands attained a maximum at 400 μg dose inasmuch as the amounts

present in animals receiving 500 μg of hormone were below those at the 400 μg level. Secretion was absent in all glands from the untreated castrates, which is in agreement with the earlier findings of others (4, 12). The results presented here and those obtained previously indicate a remarkable uniformity in the secretory response of the seminal vesicles to male hormone. In this investigation an average of 1369 mg of secretion was obtained following 500 μg of hormone daily for 20 days and, previously, Porter and Melampy (4) reported 1322 mg from animals under similar treatment.

SUMMARY

in castrate rats, the epididymides attained maximum weight with approximately 150 μg of testosterone propionate daily for 20 days, but did not reach the weight of those of intact animals because of the absence of spermatozoa and secretions. The prostates of castrates receiving approximately 150 μg of male hormone equaled in weight those of intact males, whereas the seminal vesicles and coagulating glands of animals injected with 100 μg compared with those from individuals producing testicular androgen. The amounts of secretion contained in accessory glands suggest that 150 μg of testosterone propionate would maintain seminal vesicles, prostates, and coagulating glands of castrate rats in a functional state similar to that observed in intact males. In general, the histology of glands from gonadectomized animals receiving 50 μg of hormone was similar to that of intact rats.

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ELECTRICAL CONDUCTANCE STUDIES ON AN ION EXCHANGE RESIN

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ABSTRACT

The relative conductivity of univalent ions in an exchange resin compared to that in aqueous solution indicates that the ions have similar hydration and mobility in the two media. This is further bolstered by the effect of changing solvent on the conductivity. The energy of activation for conductance indicates that the bivalent ions are as loosely held to the resins as the univalent ions, but that steric factors greatly reduce the conductivity of the bivalent ions.

The electrical conductivity of an ion exchange resin has been studied by Heymann and O'Donnell (1). They found that Amberlite IR-100 is a relatively good ionic conductor when most univalent cations are on the resin, but when in the bivalent or polyvalent ion form, the conductivity is low. They also noted that while the ratio of equivalent resin conductivity to that in water is relatively constant for most univalent ions, there is no similar regularity for the bi- and polyvalent ions. Finally, they proposed a qualitative link between conductivity and thermodynamics of resin salts, the good conductors having loosely held ions and vice versa. A comprehensive review article encompassing this subject may be consulted for other references (2).

In order to look more closely into the possibility of relating conductivity to equilibria and to generally learn more about the status of ions in exchange resins, we determined the conductivities of Dowex-50 in various forms, including some mixed forms, and in some nonaqueous solvents. We also determined the temperature coefficient of conductivity in some cases.

EXPERIMENTAL

The cell used for the conductance measurements consists of a Pyrex glass tube, 32 cm long, and of a uniform internal diameter of 1.27 cm. The electrodes, E_1 and E_2, are made of square copper rods with a circular platinum-covered-contact disc at one end and a set-screw

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[1] Department of State Grant Post-Doctorate from Fuel Research Institute, P. O. Jealgora, Distt: Manbhum, Bihar, India.

[2] Contribution No. 458. Work was performed in the Ames Laboratory of the Atomic Energy Commission.

arrangement for wire connections at the other end. The resin plug is held in position under a constant pressure between the two electrodes; the lower electrode is placed on an insulating plate and two kilogram-weights are hung symmetrically from hooks on the upper electrode. Guiding collars are provided to hold the electrodes concentric with respect to the tube.

The AC conductivity, at 1000 cycles, is measured by means of the conventional Wheatstone bridge, using an oscilloscope as zero point indicator, without capacitance compensation. Geometrical dimensions were used for the calculation of the cell constant.

The resin used in the experiments was Dowex-50. It was fractionated by sieving. In all the experiments, the fraction between 30-40 dry mesh (U.S.S.) was employed. The resin was converted into an appropriate cationic form by column regeneration technique, using chlorides or the nitrates of A.R. quality.

Resin in a particular cationic form was transferred in the wet form into the cell tube and the latter filled with distilled water and corked on both sides. The tube was brought into vertical position so that the resin settled in one end. One electrode was then introduced from the top end into the water layer, avoiding entrapping of any air bubble. The tube was then quickly inverted, and the resin began to settle down onto the electrode disc in a uniform graded layer. The other end of the tube was uncorked and the water drained off. The upper electrode was inserted into the tube, guided into position by the collar and the whole set-up was adjusted as described above. The length of the resin plug was measured by a calibrated scale on the outside of the cell tube. The conductivity measurements were made. For temperature control, the cell was suitably jacketed for water pumped from a constant temperature bath.

For determination of the conductance in media other than water, the resin was equilibrated with the corresponding medium about 4 or 5 times. Conductance measurements were then made as described earlier.

DISCUSSION

The fact that the ratio, $\frac{\lambda\, H_2O}{\lambda\, \text{Resin}}$ (Table I) is fairly constant for a group of univalent ions clearly suggests that these cations in Dowex-50 have the same hydration and the same type of freedom of motion as in aqueous solution. The size of the ratio indicates lower mobility in the resin, but part of this lowering must be attributed to limited area of contact between the small spherical particles, and part to longer path length through the maze of resin.

The similarity to solution conductivity is fortified by the studies on nonaqueous solvents (Tables IV, V, VI). The ions in the resin behave in the same manner as ions in solution, going from one solvent to another (3).

The conductivity of a randomly mixed binary resin is not a linear function of either the proportional resistivity or conductivity, but falls in between (Tables II, III). This indicates that a slow moving ion cannot block a fast moving ion, but can make the ion detour around the slow ion by a more tortuous path than would otherwise be followed.

Table I

Exchange Capacity of the Resin Plug = 28.25 m.e.
Temperature = 25°C

1 S. No.	2 Ion	3 Specific Conductance mhos x 10^{-3}	4 Length of resin plug, cm.	5 Equivalent Conductance λ_c	6 λ_o Limiting Conductance in Aqueous Soln.	7 $\frac{\lambda_o}{\lambda_c}$
1	H^+	25.34	12.2	10.940	349.82	31.96
2	Li^+	2.469	12.2	1.066	38.69	36.31
3	Na^+	3.782	11.5	1.539	50.11	32.55
4	K^+	5.732	10.9	2.212	73.52	33.24
5	NH_4^+	7.432	11.3	2.973	73.40	24.69
6	Ag^+	2.264	10.4	0.834	61.92	74.29
7	Mg^{++}	0.789	12.0	0.335	53.06	158.1
8	Ca^{++}	0.825	11.6	0.339	59.50	175.6
9	Sn^{++}	0.693	10.8	0.265	59.46	224.6
10	Ba^{++}	0.3500	10.2	0.126	63.64	503.6

Table II

Conductance of Na-H Resin at 25°C
Total Capacity of the Resin Plug = 28.25 m.e.

No.	% Na	Resistance in ohms			Conductance in mhos x 10^{-3}
		Series (calc.)	Experimental	Parallel (calc.)	
1	0.0	380	380	380	2.63
2	34.4	1074.9	800	534.7	1.25
3	53.1	1452.6	1100	684.9	.91
4	82.1	2038.4	1820	1226.	.55
5	100.0	2400	2400	2400	.42

Table III

Conductance of Ca-H Resin at 25°C
Total Capacity of the Resin Plug = 28.25 m.e.

No.	% Ca	Resistance in ohms			Conductance in mhos x 10^{-3}
		Series (Calc.)	Experimental	Parcellel (calc.)	
1	0.0	380	380	380	2.63
2	24.1	2963	600	495	1.67
3	50.7	5815	1100	746	.91
4	76.0	8527	2300	1428	.43
5	100.0	11100	11100	11100	.09

Table IV

Conductance of H-Resin in Non-Aqueous Media
Total Exchange Capacity of the Resin Plug = 28.25 m.e.
λ_M = Equivalent Conductance in Medium Under Experiment
λ_W = Equivalent Conductance in Aqueous Medium

% Solvent in Solvent-H_2O Sixture	CH_3OH		C_2H_5OH		Dioxane	
	λ_M	$\frac{\lambda_M}{\lambda_W}$	λ_M	$\frac{\lambda_M}{\lambda_W}$	$\frac{\lambda_M}{\lambda_W}$	$\frac{\lambda_M}{\lambda_W}$
0.0	10.94	1.00	10.94	1.00	10.94	1.00
10.0	9.27	0.85	8.32	0.76	8.00	0.73
25.0	7.56	0.69	5.94	0.54	5.78	0.53
50.0	4.67	0.43	3.62	0.33	3.46	0.32
75.0	2.17	0.20	1.94	0.18	1.89	0.17

Table V

Conductance of Ba-Resin in Non-Aqueous Media
Total Exchange Capacity of the Resin Plug = 28.25 m.e.
M = Equivalent Conductance in Medium Under Experiment
W = Equivalent Conductance in Aqueous Medium

% Solvent in Solvent-H_2O Mixture	CH_3OH		C_2H_5OH		Dioxane	
	λ_M	$\frac{\lambda_M}{\lambda_W}$	λ_M	$\frac{\lambda_M}{\lambda_W}$	λ_M	$\frac{\lambda_M}{\lambda_W}$
0.0	.126	1.00	.126	1.00	.126	1.00
10.0	.069	0.55	.066	0.52	.065	0.51
25.0	.039	0.31	.030	0.23	.029	0.23
50.0	.013	0.10	.012	0.10	.012	0.10

Table VI

Conductance of Ag-Resin in Non-Aqueous Media
Total Exchange Capacity of the Resin Plug = 28.25 m.e.
M = Equivalent Conductance in Medium Under Experiment
W = Equivalent Conductance in Aqueous Medium

% Solvent in Solvent-H_2O Mixture	C_2H_5OH		Dioxane	
	λ_M	$\frac{\lambda_M}{\lambda_W}$	λ_M	$\frac{\lambda_M}{\lambda_W}$
0.0	0.834	1.00	0.834	1.00
10.0	0.763	0.92	0.726	0.87
25.0	0.581	0.70	0.527	0.63
50.0	0.365	0.44	0.321	0.39
75.0	0.173	0.21	0.144	0.17

Table VII

Activation Energy for Electrical Conductivity
Between 0°C and 25°C

Ion	ΔHa, KCal
Li^+	5.1
Na^+	6.0
K^+	5.2
Mg^{++}	5.7
Ca^{++}	5.1
Sr^{++}	5.6
Ba^{++}	5.8
Zn^{++}	5.6
Ag^+	5.3
$(C_2H_5)_4N^+$	6.1

The effect of temperature is most interesting (Table VII). It has been proposed that the free energy of binding and the resistivity of the resin salt are parallel functions; a close approximation of the free energy of binding is the activation energy for conductivity rather than the conductivity itself. For a tightly bound ion this value would include not only the normal electrostatic barrier but the ΔH involved in loosening the binding of the conducting ion. Since from Table V it is apparent that the activation energies for the bivalent ions are as low as those for the better conducting univalent ions, we conclude that the conducting ions are not more tightly bound in the case of the bivalent ions. Rather, the probability that the ion will move to a new site is much lower with the bivalent ion; since two or more sites must be neutralized by the higher charged ions, it is quite reasonable that steric factors might be involved in ionic motion (4). Thus, although Ca^{++} is no more tightly held than Na^{+}, only a few Ca^{++} find themselves adjacent to a site containing two conveniently located negative charges.

The conclusion that the free energy of binding is not measured by the conductivity is further bolstered by the lack of intraresin equilibria either from "insoluble" to "soluble" ions on the resin or from ions complexed to the resin to noncomplexed ions on the resin. Neither of these equilibrium types has shown up in ion exchange equilibrium studies (5). The connection between conductivity and exchange equilibria appears remote, if any exists.

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A STUDY OF MIXED GAS ADSORPTION ON MERCURY[1]

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ABSTRACT

A pendent drop apparatus for the measurement of the surface tension of mercury and similar substances in high vacuum under conditions of maximum purity was designed, built, and demonstrated to be suitable for experimental operation. Provisions for the admission of one or more vapors of high purity to desired partial pressures were incorporated.

The dependence of mercury boundary tension on partial pressures of ethanol and heptane in gaseous mixture was investigated at 30°C, the investigation including also the pure ethanol and pure heptane gases. The surface tension of mercury was observed to be 461 ± 2 dynes/cm at 30°C. The highly accurate work of Kemball almost certainly establishes the surface tension of pure mercury at this temperature within the range 483 ± 1 dyne/cm, and from this it must be inferred that, despite tedious purification of the mercury used, its purity was not entirely satisfactory.

Adsorption of both ethanol and heptane from the gaseous mixtures was calculated using the Gibbs adsorption equation. Observed adsorption of pure heptane was in good agreement with that found by Kemball, while observed adsorption of pure ethanol was significantly less than Kemball's values.

The theory of mobile monolayers of one component is generalized to permit calculation of surface pressure dependence on partial pressures of a number of components in a mixture, given the dependence of surface pressure on pressure of pure components. Predicted surface pressures are in agreement with experiment for low to moderate total adsorption, and are significantly higher than those found experimentally at high total adsorption. The discrepancy is ascribed to multilayer adsorption.

INTRODUCTION

While there exists an extensive literature on adsorption of single component gases by solids (1), the literature on simultaneous adsorption

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[1] Based in part on a dissertation submitted by Doris Virginia Stage to the Graduate Faculty at Iowa State College in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June 1955. Contribution No. 459. Work was performed in the Ames Laboratory of the Atomic Energy Commission.

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of several components is comparatively limited, despite the fact that all gaseous adsorption purifications and separations involve such phenomena. There are substantially no data available where experimental conditions have been so chosen as to make the resulting data susceptible to treatment using a tractable theoretical model; a possible exception is the excellent work of Arnold on the mixed absorption of oxygen and nitrogen on anatase (2).

There are two limiting models for gas adsorption, namely, localized adsorption and mobile films. In the first case, each molecule adsorbed is assumed bound to a site on a surface sufficiently strongly to make explicit recognition of the partnership between a molecule and a particular site desirable; on the average such a molecule is presumed to make a great many vibrations to and fro about its equilibrium position before leaving it. Molecules in the mobile film model are assumed to experience a general attraction to the surface but not to any particular part of it, and to move on that account rather freely in two dimensions. Both models are discussed at some length by Fowler and Guggenheim (3).

The following theoretical difficulties arise in the development of equations of state based on these models:

1. The energy of interaction between molecule and surface may not be independent of coverage. Particularly in the case of localized adsorption, all sites may not be equally attractive adsorption positions, i.e., the surface may be heterogeneous. Theoretical implications of this fact have been discussed at some length by Halsey (4) and Sips (5). Where the energy of interaction is independent of coverage, the development of equations of state, considering only molecule-surface interaction, using the localized model is simple, even for an indefinite number of components (3).

2. The energy of interaction between adsorbed molecules must be considered, and in case of either model may be a complex function of surface coverage. This problem is treated for a simplified interaction law, single component adsorbate, and homogeneous surface (so-called regular localized monolayer) by Fowler and Guggenheim (3).

In addition to the theoretical difficulties presented by monolayer adsorption models, it is well known that, almost in general, adsorption becomes multilayer as gas pressures approach saturation vapor pressures, so that under these circumstances no monolayer model, however complex, can be expected to represent adsorption behavior.

Mercury was chosen as adsorbate in the present work with special consideration for the probable homogeneity of a mercury surface; since the mercury is liquid, heterogeneity due to an arbitrary distribution of crystal faces possible in solids should not arise. In addition, the excellent work of Kemball (6) on the surface tension of mercury and the adsorption of single component gases by mercury furnishes a criterion for surface purity and reproducibility in mercury not available for other adsorbates.

THEORETICAL

A rather general equation of state for a mobile monolayer is the virial equation

$$U\bar{A} = 1 + \sum_{i=1}^{\infty} \alpha_i U^i \qquad (1)$$

in which $U = \frac{\pi}{kT}$, π is the surface pressure (measured as a surface tension depression, i.e., the difference between boundary tensions in presence of and in absence of the monolayer), k is Boltzmann's constant, T the absolute temperature, $\bar{A}$ the total area divided by the number of molecules, and the α_i are constants. This equation applies to a single component film, and can be coupled with the Gibbs adsorption equation

$$dU = \Gamma \, d \ln p \qquad (2)$$

in which Γ is the surface excess, taken in the present case as the number of molecules per cm^2, so that $\Gamma = 1/\bar{A}$, and p is the pressure. The resulting differential equation

$$\left(1 + \sum_{i=1}^{\infty} \alpha_i U^i\right) \frac{d \ln U}{d \ln p} = 1 \qquad (3)$$

is solved by

$$U = Cp \exp\left[-\sum_{i=1}^{\infty} \frac{\alpha_i}{i} U^i\right] \qquad (4)$$

which is appropriate for representation of U (hence π) as a function of p and comparison with experimental results.

For two component gas adsorption the Gibbs adsorption equation becomes

$$dU = \Gamma_1 \, d \ln p_1 + \Gamma_2 \, d \ln p_2 \qquad (5)$$

and the two dimensional virial equation becomes

$$U\bar{A} = 1 + \sum_{i=1}^{\infty} C_i (x_1) U^i \qquad (6)$$

in which the quantities C_i depend on $x_1 = \frac{\Gamma_1}{\Gamma_1 + \Gamma_2}$, the surface mole fraction. To proceed further, it is necessary to make an assumption as to the character of the C_i. Where α_i and β_i are coefficients of U^i in the virial equation expansions for the two pure components, we shall assume

$$C_i = \frac{\Gamma_1 \alpha_1 + \Gamma_2 \beta_1}{\Gamma_1 + \Gamma_2}, \qquad (7)$$

i.e., that C_i is the number average of the coefficients of the constituents. It is to be emphasized that this is a simplifying assumption, and that the proper method of averaging is uncertain but probably more complex than that chosen. The analogous problem of vander Waal's constants in gas mixtures is discussed by Glasstone (7). If α_i and β_i do not differ too greatly, the value of C_i is not strongly dependent on the method of averaging selected, and the method of averaging here chosen permits evaluation of the dependence of π on P_1 and P_2 in closed form.

Combining Eqs, 5, 6, and 7 and noting that $\overline{A} = \frac{1}{\Gamma_1 + \Gamma_2}$ we obtain the partial differential equation

$$\left\{1 + \sum_{i=1}^{\infty} \alpha_i U^i\right\} \frac{\partial \ln U}{\partial \ln P_1} + \left\{1 + \sum_{i=1}^{\infty} \beta_i U^i\right\} \frac{\partial \ln U}{\partial \ln P_2} = 1 \qquad (8)$$

of which the solution is

$$U = C_1 p_1 \exp\left[\sum_{i=1}^{\infty} \frac{\alpha_i}{i} U^i\right] + C_2 p_2 \exp\left[\sum_{i=1}^{\infty} \frac{\beta_i}{i} U^i\right] \qquad (9)$$

The form of Eq. 9 is especially attractive for comparison with experimental (U, p_1, p_2) data, since the constants can be evaluated from a study of the gases individually (i.e., setting $p_2 = 0$, the dependence of U on P_1 can be established, and the constants C_1 and α_i determined; setting $p_1 = 0$, the constants C_2 and β_i can then be obtained from the dependence of U on P_2). The equation can then be checked for its application to mixtures.

It should perhaps be emphasized that the development here given is based on the mobile monolayer model, and for such a model should be quite general, but cannot properly be applied to multilayer adsorption. Failure of the equation to represent data in the neighborhood of saturation pressures is therefore to be expected.

Eq. 9 can be coupled with Eq. 5 to yield equations for the adsorption of the components as functions of partial pressure; these are

$$\Gamma_1 = \frac{\partial U}{\partial \ln p_1} = \frac{C_1}{D} p_1 \exp\left[\sum_{i=1}^{\infty} \frac{\alpha_i}{i} U^i\right] \qquad (10a)$$

$$\Gamma_2 = \frac{\partial U}{\partial \ln p_2} = \frac{C_2}{D} p_2 \exp\left[\sum_{i=1}^{\infty} \frac{\beta_i}{i} U^i\right] \qquad (10b)$$

where

$$D = 1 + C_1 p_1 \sum_{i=1}^{\infty} \alpha_i U^{i-1} \exp\left[-\sum_{i=1}^{\infty} \frac{\alpha_i}{i} U^i\right] + C_2 p_2 \sum_{i=1}^{\infty} \beta_i U^{i-1} \exp\left[-\sum_{i=1}^{\infty} \frac{\beta_i}{i} U^i\right] \quad (10c)$$

EXPERIMENTAL

The pendent drop technique was selected for determination of surface tensions in the present work for the following reasons:

1. It is a completely static method;
2. It is suitable for use in high vacuum systems;
3. The theory of the method has been highly developed, so that it is an absolute method.

The differential equation of the pendent drop is

$$\frac{d^2Z}{dx^2} + \frac{1}{x}\frac{dZ}{dx}\left[1 + \left(\frac{dZ}{dx}\right)^2\right] = \left[\frac{2}{b} - \frac{g\sigma}{\gamma} Z\right]\left[1 + \left(\frac{dZ}{dx}\right)^2\right]^{3/2} \quad (11)$$

in which

Z = vertical coordinate measured from the bottom of the drop taken as origin.
X = horizontal distance to axis of drop.
g = gravitational constant.
σ = density of drop phase minus density of medium in which drop is suspended.
b = radius of curvature at the origin.
γ = boundary tension of the liquid forming the drop.

This equation has so far resisted all efforts at analytical integration, but has been integrated numerically by Fordham (8), who presents his results in a manner well suited to calculation of surface tensions from measurements of drop dimensions. The surface tension is given by

$$\gamma = \frac{g \sigma d_e^2}{H} \quad (12)$$

in which d_e is the maximum diameter of the drop, d_s is the diameter of the drop at a distance d_e above the origin, and H is a function of the ratio d_s/d_e (Fig. 1). It is the function H which is tabulated by Fordham, and he has done this in sufficient detail that the function H can be established for any value of the ratio d_s/d_e which is a possible result of measurement with an uncertainty not greater than 0.005 per cent.

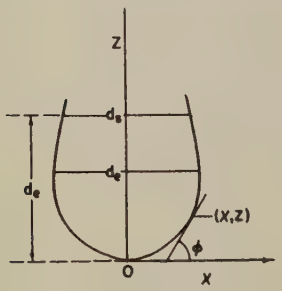

FIGURE 1. THE PENDENT DROP

The pendent drop method, for all its theoretical advantages, is experimentally demanding with systems such as those under investigation. The mercury pendent drops were approximately 3 mm in maximum diameter. A 1 per cent error in d_e would cause a 2 per cent error in γ due to the d_e^2 term alone, but the character of the d_s measurement is such that an overestimation of d_e causes an underestimation of d_s, and hence a still greater underestimation of the ratio d_s/d_e on which H depends. Because of this, a 1 per cent error in d_e will lead to an error of approximately 4 per cent over the greater part of the possible d_s/d_e range.

Correspondingly, for an error of 0.4 per cent, which is about as large as one would care to tolerate, it is necessary to establish distance measurements to 0.1 per cent. This means that in the present case it is necessary to establish linear measurements to within 3 μ. Since this measurement must be made on a mercury drop suspended in a closed system, it is necessary to rely on profile projection methods for the measurement. An apparatus used for this purpose by Andreas, Hauser, and Tucker (9) is shown in Fig. 2. The optical system used in the present work was similar in layout, and contained components as follow:

1. Light was furnished by a Fish-Schurman 40 watt zirconarc lamp, with equivalent focal length of 16.5 mm and source diameter of 0.94 mm, reported by the manufacturer to be well corrected for spherical aberration, coma, and color. This replaced the mercury arc lamp of Fig. 2.

2. The microscope objective was a 35 mm f/2.3 Bausch and Lomb "Baltar" lens reported by the manufacturer to have extreme flatness of field, high resolving power, and to be well corrected for all aberrations. Neither in the case of the zirconarc lamp nor in the case of the Baltar lens was it possible to obtain from the manufacturers quantitative information concerning magnitudes of remaining aberrations.

3. The lens was mounted on a camera which consisted of a focusing device, bellows, and plate holder which could hold either photographic plates or a ground glass screen. Camera and projector were mounted on rollers on a sturdy optical bench; hence, the camera and projector could be rolled as desired along the optical

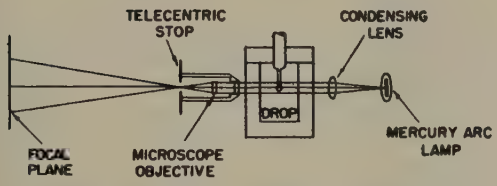

FIGURE 2. APPARATUS OF ANDREAS, HAUSER & TUCKER

bench, the bellows could be extended or compressed, and the optical bench orientation changed by means of screws attached to each of its four feet to obtain optimum focusing and alignment.

4. The drop was formed inside an American Instrument Co. 50 mm pathlength absorption cell modified as shown in Fig. 3. The drop forming tip was made of 2 mm inside diameter pyrex tubing, and the end of it was ground and polished. Optical properties of the cell were stated by the manufacturer to be as follows: "parallelism of glass-air interfaces: within 0.01 mm; flatness of windows: within 6 wavelengths; parallelism of faces of each window: within 5 minutes.

FIGURE 3. CELL AND DROP FORMING TIP: ABOVE, SIDE VIEW; BELOW, END VIEW.

The optical system was aligned as follows: camera and light source were aligned so that light from the source entered the center of the projection lens and formed a circular spot on the ground glass screen at the back of the camera. If alighment were good, the circular spot became uniformly smaller and larger as the apertures of the projection and condensing lenses were closed and opened. The optical bench was then adjusted so that the portion of light from the source reflected by the cell window fell on the center of the source lens, while, at the same time, the image of the drop forming tip fell in a central position on the ground glass plate.

A plumb line, consisting of a lead drop and nylon thread, was fastened to the camera in front of the plate holder, and its shadow on the photographic plate served as a vertical reference line in subsequent measurements made on the plate. Photographs were made at 10 second exposures on Kodak 548-GH spectroscopic High Resolution plates; drop images appeared sharp and clear under magnification of the travelling microscope of the measuring machine used.

Measurements on photographs were made by means of a Cambridge Universal Measuring Machine (Cambridge Instrument Co., Ltd., London) which permitted measurements of distances in both x and y directions with a reproducibility of 0.002 mm. The diameter of the dropping tip was measured directly before its insertion in the absorption cell; its mean diameter obtained from 40 measurements was 3.825 ± 0.006 mm (deviation is average from the mean). The ratio of drop tip diameter in a photograph to true drop tip diameter then furnished the magnification ratio on the photograph.

As a check on the optical system a steel ball 1/8" in diameter, supplied by Industrial Tectonic Co., guaranteed in absolute dimensions to 10 microinches and in sphericity to 10 microinches, was placed in the cell in, as nearly as possible, the same position as the drop, photographed, and the tip diameter recomputed using the ball as magnification standard. The result, 3.829 mm, agreed with the value obtained by direct measurement within experimental error.

The adsorption apparatus is shown in Fig. 4. All glass parts, prior to assembly, were cleaned with concentrated nitric acid, chromic acid, or both, thoroughly rinsed with distilled water, and dried. The system could be readily evacuated to pressures less than 10^{-5} mm of mercury by means of an H. S. Martin Co. diffusion pump coupled to a Welch Duo-Seal forepump. In Fig. 4, A is a primary mercury still, connected by the glass tube below it to a jar of mercury exposed to atmospheric pressure. When the system is evacuated, mercury rises to A and, when the electric heater surrounding A is turned on, distills, is condensed by a water condenser above A, and flows into the secondary mercury still B. When a sufficient amount of mercury has distilled into B, the heater for A is turned off, the mercury in A then serving to seal the system from the external world. The heater to B is turned on with drop control D open, and the mercury can then be further purified by cyclic distillation, following the path BCDEFB. M and N are liquid nitrogen traps; pressures in evacuated systems were measured by means of a National Research Corporation thermocouple gauge and an ion gauge.

The system was so constructed that any stopcocks were separated

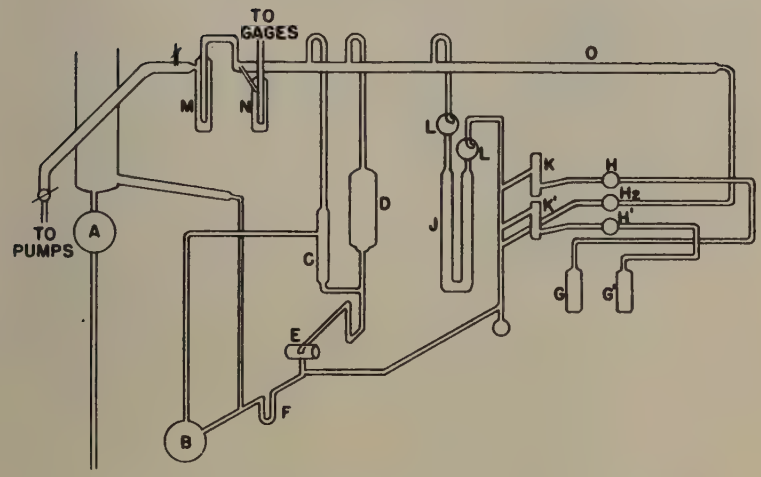

FIGURE 4 PENDENT DROP APPARATUS, VACUUM SYSTEM

from mercury by intervening liquid nitrogen traps to avoid contamination by mercury from vapors of stopcock grease. This precaution has been recommended by Kemball (6).

The drop control mechanism (D in Fig. 3) is shown in detail in Fig. 5. The stainless steel nut is held in place by indentations in the shoulder in the surrounding pyrex container, so that when the Alnico bar magnet is caused to rotate by rotating the external assembly about the screw axis, the stainless steel screw advances or retracts through the nut and the plunger can be made to displace mercury into the dropping tip. The glass sleeve protects the mercury from direct contact with steel. The mercury reservoir is connected to the drop control apparatus by a button seal, so that after the plunger has passed this seal there is a positive drop control.

The portion of the closed system thus far described suffices for the determination of the surface tension of pure mercury, and the balance of the apparatus serves to control gas admission to the measurement cell at desired partial pressures. In Fig. 4, J is a manometer constructed of precision bore 5/8" tubing for measurement of total pressure, and L and L' are splash bulbs for this manometer, which served to prevent loss of mercury when the manometer was outgassed with heating prior to use. Connections from C, D, and J in Fig. 4 to the vacuum manifold were led into the top of the manifold, so that any mercury which may have reached the manifold due to outgassing or other accidents was denied access to these sections. The system for gas storage, inlet, and control consists of reservoirs G and G', seamless bellows metal Fulton valves H, H', and H_2, and back diffusion blocks K and K', and is shown in detail in Fig. 6. Liquids (in the present work N-heptane and ethanol) could be sealed into G and G', outgassed by freezing and evacuating G and G' by opening H', H, and H_2, closing these valves and allowing the

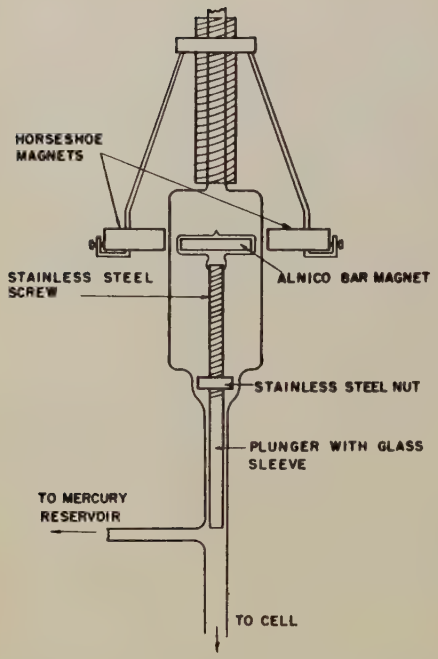

FIGURE 5 DROP CONTROL

liquids to warm, and repeating this operation a number of times (until no bubbles were observed in the liquids on melting). K and K' were filter tubes containing fine pore sintered glass plates on which layers of mercury about 3 mm in depth were placed; this arrangement prevented back diffusion of vapors into the reservoirs and indicated (by bubbling rate) the rate of gas flow into the system.

Mercury could be frozen in the U-tube F by means of a dry ice acetone trap, so that, during the adsorption experiments, the mercury still B was isolated from the gas system. By allowing the mercury to extend some distance above the U tube, condensation of vapors on the mercury was avoided.

A mounting which allowed production of drops nearly free of vibration was essential for observations with a semblance of accuracy. The apparatus previously described was mounted on the system shown in Fig. 7. The rack consisted of an angle iron frame with aluminum cross bars at approximately 6" intervals, and was very sturdy. This was mounted on a very heavy piece of soapstone 5' x 2 1/2' x 3", one end of which was supported on hard rubber (vibration damper; alternate layers of 1/2" fiber board and 1/2" foam rubber repeated about 4 times also served well for this purpose) and the other end supported on an inflated 4.00-8 inner tube (force transmitter). The soapstone slab-rubber-inner tube arrangement was suggested by Dr. P. H. Carr of the Department of Physics, Iowa State College, and proved to be by far the most effective antivibration mounting of a large number tried.

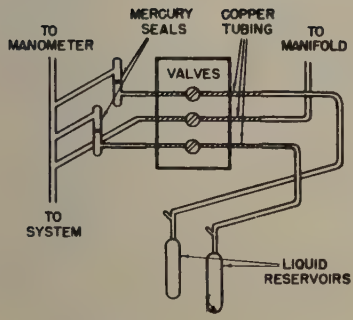

FIGURE 6 VAPOR INLET SYSTEM

Because of the size of the apparatus conventional temperature control was very difficult. The measurements here reported were performed during a portion of the summer during which room temperature varied only a few degrees from 30°C. When room temperature was less than 30° two infrared lamps were arranged so that a fan blowing past them blew warm air toward the cell. If room temperature was above 30°C a metal coil through which cold water flowed was substituted for the infrared lamps. By use of these devices temperature in the neighborhood of the cell could be maintained at 30.0 ± 0.2°C for a period of several hours.

Pressure readings were made on the manometer using a cathetometer.

The mercury was triply distilled mercury obtained from the Goldsmith Bros. Smelting and Refining Co. It was first purified by the method of Bartell and Bard (10). The mercury was caused to fall repeatedly in fine droplets through a column of 18 per cent nitric acid, after which it was washed several times in distilled water, filtered, distilled twice in air, filtered, and then distilled in vacuum. In a second procedure the mercury was first shaken with concentrated nitric acid, allowed to fall dropwise through the 18 per cent nitric acid column, stirred with sulfuric acid, air distilled three times, with intervening filtrations, and finally distilled in vacuum. In both cases, the mercury was then introduced into the system, as previously explained, by vacuum distillation and was further purified by cyclic distillation for a period of several days. Samples of mercury prepared by either method had identical surface tensions--within the limit of experimental error.

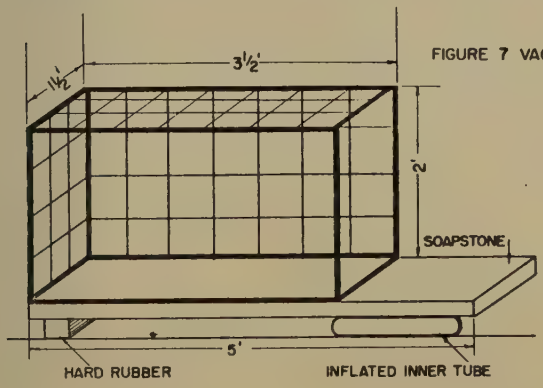

FIGURE 7 VACUUM RACK AND MOUNTING

The ethanol was purified by distillation from magnesium ethylate through a 30 plate Oldershaw column at reflux ratio 10 to 1; the fraction used had a boiling range 78.72 to 78.75°C corrected to 760 mm.

The heptane was purified by fractional freezing according to the method of Aston amd Mastrangelo (11), then distilled.

Total impurities were not in excess of 0.7 mole per cent, and these presumably were largely heptane isomers.

RESULTS

The surface tension obtained for mercury was 461 dynes/cm at 30°C; approximately this value was obtained repeatedly so long as cyclic distillation had been continued for three days or more and was obtained from numerous separate batches of mercury. No steady value differing from 461 dynes/cm by more than 1 per cent was obtained, with most values observed falling in the range 460-462 dynes/cm.

While reported values of the surface tension of mercury range from under 400 dynes/cm to 513 dynes/cm (12), the most careful and extensive work reported to date appears to be that of Kemball (6), and from his results it is most probable that the correct surface tension for pure mercury is within 1 dyne/cm of 483 dynes at 30°C.

Since impurities almost invariably lower surface tensions, usually in a more dramatic fashion the greater the surface tension of the substance under investigation, we are almost forced to conclude that our mercury was less pure than that prepared by Kemball, although our purification procedures closely paralleled his.

Experimental results for depression of surface tension of mercury, π, by pure ethanol vapor as a function of pressure are shown in Fig. 8; the corresponding results for pure heptane vapor are shown in Fig. 9. These results, as well as the mixed adsorption results, are based on measurements after equilibration periods of approximately one hour, which experience showed to be more than sufficient for the attainment of steady values. In both cases, satisfactory representations of the data were obtained by Eq. 4, with the virial summation being limited to the first two terms. Curves in Figs. 8 and 9 are calculated on the basis of Eq. 4; parameters used are shown in the figures.

Experimental results for the depression of surface tension of mercury in ethanol-heptane mixtures are shown in Fig. 10. In obtaining these results the ethanol partial pressures were set at the values indicated for each curve initially; heptane was then allowed to enter and the heptane partial pressure for each point computed as the difference between total pressure read on the manometer and the set pressure of ethanol. Points are experimental, curves are calculated from Eq. 9 using the parameters determined for the pure adsorbate (i.e., the same parameters used to represent the data in Figs. 8 and 9.

The data for the lowest partial pressure of ethanol (11.5 mm) are rather well represented by the calculated curve for all partial pressures of ethanol investigated; the date for the highest partial pressure of ethanol (41.2 mm) are well represented for partial pressures of heptane lower than 20 mm but for higher heptane partial pressures the calculated

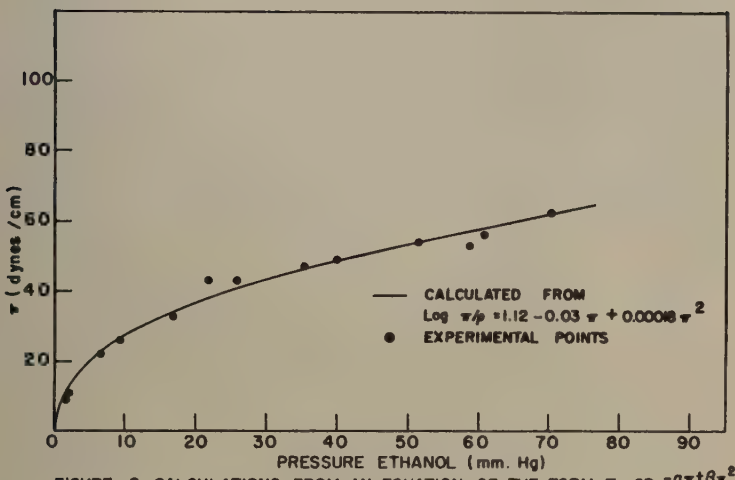

FIGURE 8 CALCULATIONS FROM AN EQUATION OF THE FORM $\Pi = CPe^{-\alpha\pi+\beta\pi^2}$ COMPARED WITH EXPERIMENTAL VALUES FOR ETHANOL

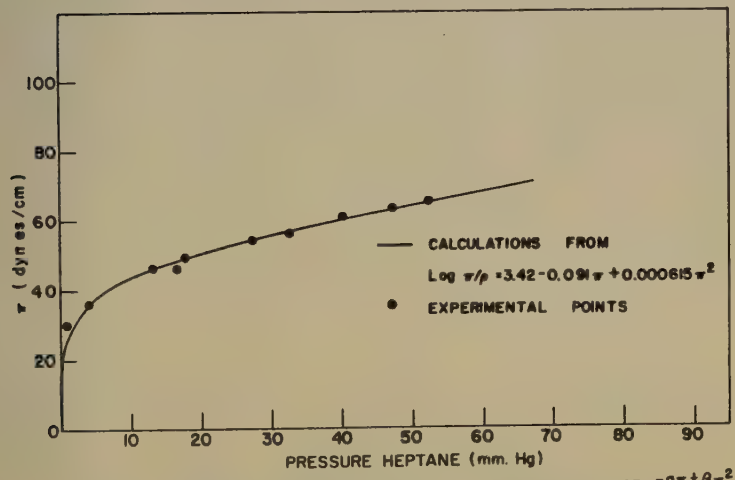

FIGURE 9 CALCULATIONS FROM AN EQUATION OF THE FORM $\pi = CPe^{-\alpha\pi+\beta\pi^2}$ COMPARED WITH EXPERIMENTAL VALUES FOR n-HEPTANE

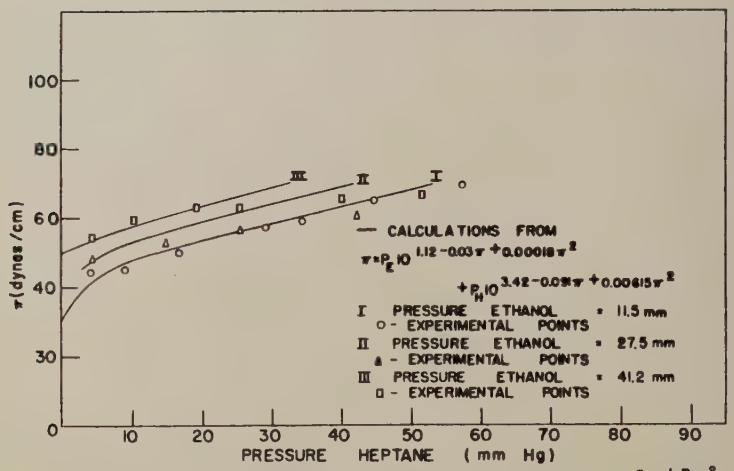

FIGURE 10 CALCULATION FROM AN EQUATION OF THE FORM $\pi = C_1 P_1 e^{-\alpha_1 \pi_1 + \beta_1 \pi^2} + C_2 P_2 e^{-\alpha_2 \pi + \beta_2 \pi^2}$ COMPARED WITH EXPERIMENTAL VALUES FOR n-HEPTANE-ETHANOL MIXTURES

depressions are significantly greater than those observed. In view of the large total pressure of condensable vapors, this deviation is almost certainly due to multilayer adsorption. If a surface pressure (surface tension depression) is computed on the assumption that all adsorbed molevules are in a monolayer, when actually some of the molecules are above this layer (and hence fewer are in it), the surface density of molecules in the first layer, and hence the surface pressure, will be overestimated. The observed deviation is therefore in the expected direction. The data for the intermediate partial pressure of ethanol appear to be inconsistent and erratic; their deviation from the calculated curve may be more due to erratic data than to inadequate theory.

The surface tension depression of mercury by ethanol and heptane vapors, therefore, appears reasonably represented by Eq. 9 for moderate pressures at 30°C; the limit of application is approximately

$$\frac{P_H}{P_H^{\circ}} + \frac{P_E}{P_E^{\circ}} < 0.8$$

For ideal solutions, if the left side of this equation exceeded unity the gas would liquefy. Within the range of application of Eq. 9, the adsorption of the components is given by Eq. 10, with parameters

$kTC_E = 10^{1.12}$ $\qquad$ $kTC_H = 10^{3.42}$

$\alpha_1 = 2.303\ kT \times 0.03$ $\qquad$ $\beta_1 = 2.303\ kT \times 0.091$

$\frac{1}{2}\alpha_2 = -2.303\ (kT)^2 \times 1.8 \times 10^{-4}$ $\qquad$ $\frac{1}{2}\beta_2 = -2.303\ (kT)^2 \times 6.15 \times 10^{-3}$

The symbols C_E, α_1 and α_2 pertain to ethanol, C_H, β_1 and β_2 to heptane.

CONCLUSIONS

The adsorption of gaseous ethanol-heptane mixtures by mercury was investigated theoretically and experimentally. The virial treatment of mobile monolayers of one component was generalized to two components and found to apply satisfactorily over the pressure range in which adsorption of monolayer character could be expected. In the course of the experimental investigation, apparatus suitable for controlled atmosphere investigation of boundary tensions, including boundary tension measurements in high vacuum, was designed, constructed, and shown to be practical in use.

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PASSAGE OF CHERRY VIRUS THROUGH PRUNUS ROOT GRAFTS[1]

O. F. Hobart, Jr.[2]

Demonstration that there was some tendency for virus to spread from infected to adjacent cherry trees in nursery blocks in southwest Iowa (1) led to a consideration of the possibility that virus might pass from one tree to another in the row through natural root grafts. The proximity of trees in the nursery row would seem to point to such a possibility.

The experiments reported here involved determination of virus passage between manually root grafted pairs of, 1) seedling understock trees of the same Prunus species, 2) seedling understock trees not of the same species, and 3) nursery trees propagated on their respective rootstocks. There were also some observations of excavated roots of closely spaced adjacent trees in the nursery row and of roots of nursery grown trees immediately after digging.

PROCEDURE

Roots of pairs of trees were approach grafted and wrapped securely (Fig. 1), first with nurserymen's cloth tape and then with rubber budding strips. Each such grafted pair of trees was set in greenhouse soil in an eight-inch clay pot. One member of each pair was inoculated at time of bud break by inserting buds containing a known source of virus. The eight sources of virus-containing budwood (all supplied by Dr. J. D. Moore, University of Wisconsin) used for inoculation were as follows: necrotic ring spot - B-1-12, G-2-1, and G-5-1; necrotic ring spot and yellows - B-1-4; necrotic ring spot, yellows, and prune dwarf - B-3-22 and G-20-5; necrotic ring spot (recurrent) and yellows - M-6-19 and S-5009. There were daily observations for symptom expression commencing one week after inoculation and continuing for eight weeks thereafter. Symptoms in inoculated members of pairs appeared in from three to five weeks after inoculation and in uninoculated members from one to three weeks later.

All trees were indexed on Prunus tomentosa prior to grafting to insure initial freedom from virus. Final checks were made, by indexing, for presence or absence of virus in all uninoculated members of pairs that failed to express symptoms. Of the uninoculated members that expressed symptoms, one representative of each group was likewise indexed. All root grafts were checked at the end of experiments to determine success or failure of root graft union.

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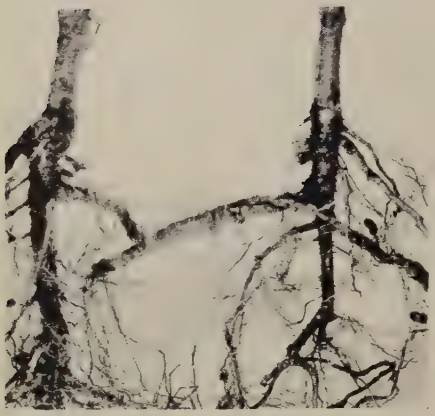

Fig. 1. Root graft of a pair of Prunus understock seedlings. (Grafting rubber was wrapped around nurserymen's tape to press roots together firmly.)

Intraspecies passage.

The roots of 12 pairs each of seedling trees of P. mahaleb, P. avium var. Mazzard, and P. americana were grafted together, the pairs set in pots and one tree of each pair inoculated at bud break with a known source of virus. Three pairs of each species were thus inoculated with one of four virus sources. One or both trees of five pairs of P. americana died early in the experiment.

Observations of graft unions and symptom expression by all pairs of living trees in the experiment are recorded in Table 1. Both trees in all but one of the 31 pairs showed positive symptoms. Bud graft inoculation and root graft both were unsuccessful in this one case, and both trees were virus-negative, by indexing on P. tomentosa, at the end of the experiment. By the same criterion, eleven uninoculated members with symptoms, one for each species and virus source, were virus-positive at the end of the experiment.

Interspecies passage.

The roots of six seedling trees of P. mahaleb were grafted to six P. avium, six P. mahaleb to six P. americana, and six P. avium to six P. americana. One member of three pairs of each of the three species combinations was inoculated with virus source B-1-12 and one member of each of the three remaining pairs with virus source G-5-1. Trees of one pair, P. avium grafted to P. americana died early in the experiment. P. mahaleb was inoculated in all pairs involving this species; in the pairs of P. avium grafted to P. americana, P. avium was inoculated. The inoculated species of the pair is listed first in each case in Table 1, which contains recorded observations of successful graft unions and symptom expression by all pairs of live trees in the experiment. Fig. 2 shows positive symptoms on leaves from both members of a pair of P. mahaleb grafted to P. americana. Both trees in all but one of the 17 pairs showed positive symptoms. Bud graft inoculation and root graft were both unsuccessful in this one case and both trees were virus-negative, by indexing, at the end of the experiment. Six uninoculated

Table 1. Evidence of virus passage through root grafts between pairs of three seedling understock Prunus species and between pairs of cherry and peach nursery trees.

Grafted seedlings or trees	Virus source	Pairs grafted and alive	Unsuccessful root grafts	Symptom expression: inoculated pos.	inoculated neg.	uninoculated pos.	uninoculated neg.
SEEDLINGS							
P. mahaleb	B-3-22	3	0	3		3	
	G-2-1	3	0	3		3	
	G-20-5	3	0	3		3	
	M-5-74	3	1	2	1*	2	1
P. avium var. Mazzard	B-3-22	3	0	3		3	
	G-2-1	3	0	3		3	
	G-20-5	3	0	3		3	
	M-5-74	3	0	3		3	
P. americana	G-20-5	3	0	3		3	
	M-5-74	3	0	3		3	
	M-6-19	1	0	1		1	
P. mahaleb** to P. avium	B-1-12	3	0	3		3	
	G-5-1	3	0	3		3	
P. mahaleb to P. americana	B-1-12	3	0	3		3	
	G-5-1	3	1	2	1*	2	1
P. avium to P. americana	B-1-12	2	0	2		2	
	G-5-1	3	0	3		3	
TREES							
P. cerasus var. Montmorency on P. mahaleb rootstocks	B-1-12	3	1	3		2	1
	B-3-22	3	1	3		2	1
	M-6-19	3	0	3		3	
P. persicae var. Halehaven on Lovell rootstocks	B-1-4	3	0	3		3	
	G-2-1	3	1	3		2	1
	S-5009	3	0	3		3	

* Bud-graft inoculation unsuccessful.

** Inoculated species listed first.

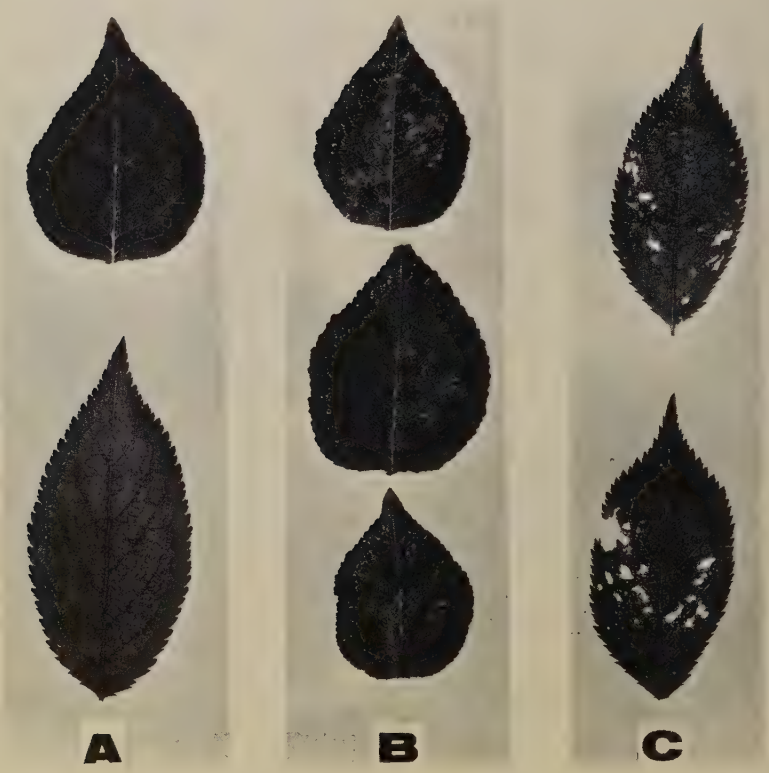

Fig. 2. Leaves from left to right:

a. Leaves of healthy trees, Prunus mahaleb above and P. americana below.

b. Leaves from the inoculated member (P. mahaleb) of a root-grafted pair of understock seedlings.

c. Leaves from the uninoculated member (P. americana) of the same root-grafted pair showing the characteristic symptoms of necrotic ring spot.

(nonbudded) members with symptoms, one for each species combination and virus source, were virus positive, by indexing on P. tomentosa.

Passage between root-grafted pairs of nursery trees.

It seemed worth while to determine whether virus would pass from an infected scion to the rootstock, thence via root graft to the rootstock of another tree, and eventually to its scion.

The roots of nine pairs of P. cerasus var. Montmorency propagated on P. mahaleb seedling rootstocks were grafted together. One member of each of three pairs was inoculated with virus source B-1-12, three pairs with virus source B-3-22, and the three remaining pairs with virus M-6-19.

All 18 trees remained alive for the duration of the experiment. There was root graft failure with two pairs and there was symptom expression on all trees except the uninoculated members of those two pairs. These two trees were virus-negative by indexing on P. tomentosa; three uninoculated members of other pairs, one for each virus source, were virus-positive by indexing. Data are included in Table 1.

In a similar experiment with three varieties of peach, P. persicae, propagated on Lovell peach seedling rootstocks, there was considerable mortality of trees except with variety Halehaven. With this variety, all 18 trees remained alive, there was only one unsuccessful root graft and there was virus passage in all but this pair. Tabulated results with this variety are also included in Table 1.

Occurrence of root grafts in the nursery row.

To determine whether or not root grafts between adjacent trees in the nursery actually occur, the root systems of 14 closely set Montmorency cherry trees in commercial blocks were exposed by carefully removing the soil from around the roots with an ice pick. No root grafts were found. In fact, two roots about one-half inch in diameter, one each from two adjacent trees, were "grooved", each by virtue of growth in proximity to the other, but definitely without any growth union. Also, during digging operations in the same block, 157 pairs of closely growing two-year trees were carefully pulled from the soil by hand. No root grafts were observed.

On the other hand, in a row of 300 Elberta and a row of 300 Champion one-year peach trees, 15 and 14 root grafts, respectively, were observed at time of digging.

SUMMARY AND CONCLUSIONS

Passage of virus occurred between 30 root-grafted pairs of seedling trees of P. mahaleb (11 pairs), P. avium var. Mazzard (12 pairs), and P. americana (7 pairs), in which one member of the pair was inoculated, both members were observed for symptom expression, and appropriate checks made, by indexing, for presence or absence of virus.

By a similar procedure virus passage was demonstrated between six pairs in which P. mahaleb had been root grafted to P. avium, five pairs in which P. mahaleb had been root grafted to P. americana, and five pairs in which P. avium had been root grafted to P. americana.

There was evidence of virus passage from scion to rootstock, thence via root graft to another rootstock and to its scion, in seven root grafted pairs of cherry and eight pairs of peach nursery trees.

No root grafts were found by carefully excavating roots of 14 closely adjacent Montmorency cherry trees in the nursery row; likewise, none were found by carefully pulling by hand 157 pairs of trees in the same block during nursery digging operations.

There is no doubt that virus can pass from one tree of Prunus to another via root grafts, but it appears that such root grafts, if they occur, are too rare to account for much spread of virus among sour cherry trees in the nursery.

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FULL SIB AND PARENT OFFSPRING CORRELATIONS IN SYMMETRICAL RANDOM MATING POPULATIONS WITH THE FREQUENCY OF THE MORE FAVORABLE ALLELE THE SAME AT ALL LOCI[1]

Theodore W. Horner[2]

1. Introduction

Parent offspring and full sib correlations for an additive model with dominance were derived by Fisher (1918) for a random breeding population. Horner and Kempthorne (1955) gave formulas for the parent offspring and full sib covariances for a random mating population with gene frequency equal to 1/2 at all loci for which the genotypic value could be expressed as a function of the number of nulliplex (--), the number of simplex (+-) and the number of duplex (++) loci; such a relationship of genotypic value to genotype being referred to as a symmetrical model. Particular formulas were given for the complementary, duplicate factor, multiplicative and optimum number models. In the present paper parent offspring and full sib covariances and correlations are examined under the assumption that the frequency of the plus allele is the same at all loci, say p.

The assumption of the same frequency of the plus allele seems reasonable since selection preasure operating upon genotypes whose values are given by a symmetrical model would probably tend to equalize the frequency of the plus gene at all loci. Parent offspring and full sib covariance formulas yield information on the biases in estimates of additive genetic variance obtained by doubling the parent-offspring and full-sib covariances and how the biases change with gene frequency when epistasis is present and ignored.

2. Parent Offspring and Full Sib Covariances

Formulas[3] for these covariances, genotypic variances of the random mating population, and additive genetic variances are shown in Table I for an additive model with dominance, a complementary model, a duplicate factor model, and an optimum number model. In these formulas p and q represent the frequencies of the + and - alleles, respectively, and n the number of loci. The mathematical representation of these models, with the exception of the first, is described by Horner and Kempthorne (1955) and summarized by Horner (1956). The additive model with dominance is represented by the equation

$$\text{Genotypic value} = (u + au)\, y_1 + 2uy_2$$

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[3]The derivations of these formulas are available in mimeographed form upon request.

where y_1 is the number of (+-) loci, y_2 is the number of (++) loci, u is the half distance between two homozygotes and a is a measure of degree of dominance. The parent offspring and full sib genotypic correlations are

$$\rho_{P,O} = \frac{Cov(P,O)}{\sigma^2_G} \quad \text{and} \quad \rho_{F,S} = \frac{Cov(F,S)}{\sigma^2_G}$$

where Cov(P,O), Cov (F,S) and σ^2_G are respectively the parent offspring and full sib covariances and the genotypic variance of the random mating population.

3. Parent Offspring and Full Sib Correlations for Special Cases.

Relationships between these correlations and gene frequency are shown in graphs 1a - 1f. These correlations which are all less than one-half decrease as the number of pairs in the interacting set of loci increases. The full sib correlations are higher than the parent offspring correlations. Graphs 1a and 1b show, respectively, parent offspring and full sib correlations for the additive model with differing degrees of dominance. The degree of dominance is measured by the parameter "a" and the four curves on graphs 1a and 1b are: a = 0, no dominance; a = 0.5, partial dominance; a = 1, complete dominance; a = 1.5, over dominance.

These curves have a minimum of $\frac{1-a^2}{2-a^2}$ (parent offspring) and $\frac{4-3a^2}{8-4a^2}$ (full sib) at $p = \frac{1+a}{2}$ for $0 \leq a \leq 1$, and a minimum of zero (parent offspring) and $\frac{1}{4}$ (full sib) at $p = \frac{1+a}{2a}$ for $a \geq 1$.

A peculiar feature of the additive model with dominance is that the parent offspring and full sib correlations approach 1/2 as p approaches 1 for all values of a except a = 1. When a = 1, the parent offspring and full sib correlations approach 0 and 1/4, respectively. When a = 1, a factor (1-p) cancels in numerator and denominator resulting in the very simple formulas:

$$\rho_{P.O.} = \frac{1-p}{2-p} \quad \text{and} \quad \rho_{F.S.} = \frac{4-3p}{8-4p} \quad .$$

Complementary Model (Graph 1c). These correlations when graphed against gene frequency result in concave downward curves, which approach zero and 1/4, respectively, as $p \longrightarrow 1$ for the parent offspring and full sib correlations, regardless of the number of loci in the interacting set. As $p \longrightarrow 0$, the parent offspring and full sib correlations both approach $(1/2)^n$.

Duplicate factor model (Graph 1d). The curves are concave upward and approach 0 and $(1/4)^n$ as $p \longrightarrow 1$ for the parent offspring and full sib correlations. As $p \longrightarrow 0$, all curves approach 1/2.

Complete dominance multiplicative model. Results for this model can only be studied by choosing values of b and e. The values chosen were those considered by Horner (1952), i.e., (i) b = e = 1.1, (ii) b = e = 1.4 and an additional case (iii) b = e = 1.06. This latter value was selected by supposing that the range in bushels per acre for a certain variety of corn was 96 to 30 and that twenty pairs of multiplicative genes

Table I. Covariances and Variances

Model	Parent Offspring Covariance
Additive with dominance	$pq\left[1+(1-2p)a\right]^2 u^2$
Complementary	$\left[p^2+p(1-p^2)\right]^n-(1-q^2)^{2n}$
Duplicate factor	$q^{3n}(1-q^n)$
Multiplicative	$\left[p^4b^2+p^3q(b+e)^2+2p^2q^2e(b+e+1)+pq^3(e+1)^2+q^4\right]^n - \left[p^2b+2pqe+q^2\right]^{2n}$
Optimum number	$npq\left[2d+(q-p)(2n-1)\right]^2+2n(n-1)p^2q^2$
	Full Sib Covariance
Additive with dominance	$pq\left[1+(1-2p)a\right]^2u^2+p^2q^2a^2u^2$
Complementary	$\left[1-2q^2+\frac{1}{4}q^2(1+q)^2\right]^n-(1-q^2)^{2n}$
Duplicate factor	$\left[\frac{q(1+q)}{2}\right]^{2n}-q^{4n}$
Multiplicative	$\left[p^4b^2+p^3q(b+e)^2+2p^2q^2(e^2+\frac{(b+2e+1)^2}{8})+pq^3(e+1)^2+q^4\right]^n-\left[p^2b+2pqe+q^2\right]^{2n}$
Optimum number	$npq\left[2d+(q-p)(2n-1)\right]^2+np^2q^2+2n(n-1)p^2q^2$
	Genotypic Variance
Additive with dominance	$2pq\left[1+(1-2p)a\right]^2u^2+4p^2q^2a^2u^2$
Complementary	$(1-q^2)^n-(1-q^2)^{2n}$
Duplicate factor	$q^{2n}-q^{4n}$
Multiplicative	$(p^2b^2+2pqe^2+q^2)^n-(p^2b+2pqe+q^2)^{2n}$
Optimum number	$2npq\left[2d+(q-p)(2n-1)\right]^2+4np^2q^2+8n(n-1)p^2q^2$
	Additive Genetic Variance
Additive with dominance	$2pq\left[1+(1-2p)a\right]^2u^2$
Complementary	$2npq^3(1-q^2)^{2(n-1)}$
Duplicate factor	$2npq^{4n-1}$
Multiplicative	$2npq\left[q+(p-q)e-pb\right]^2(q^2+2pqe+p^2b)^{2(n-1)}$
Optimum number	$2npq\left[2d+(q-p)(2n-1)\right]^2$

with complete dominance were responsible for this range. The ratio of the largest to the smallest genotypic value would be then $b^{20} = 3.2$, which yields a value of $b = 1.06$.

Regardless of the value of b or n, the parent offspring correlation approaches 1/2 as $p \longrightarrow 0$ and zero as $p \longrightarrow 1$ and the full sib correlation approaches 1/2 as $p \longrightarrow 0$ and 1/4 as $p \longrightarrow 1$ for the multiplicative model with complete dominance, the curves being concave downward. Since the parent offspring and full sib curves are essentially identical for the additive model with dominance and the cases examined of the multiplicative model with complete dominance, no special graphs are shown.

Optimum number model (Graphs e,f). These curves which are concave upward have a minimum of $\frac{n-1}{4n-2}$ (parent offspring) and 1/4 (full sib) at

$$p = \frac{d + n - \frac{1}{2}}{2n-1} = p_m \text{ , say for } 0 \leq d < n.$$

At p_m the additive genetic variance is a minimum and the population mean is at its maximum value (Horner, 1956). For values of p less than p_m, the regression of genotypic value on number of plus genes is positive and for values greater than p_m, the regression is negative. The correlations do not go zero when $\sigma^2_A = 0$, since $\sigma^2_{AA} \neq 0$ when $\sigma^2_A = 0$. When d = n, a minimum of $\frac{9n-3}{20n-6}$ (parent offspring) and $\frac{18n-5}{40n-12}$ (full sib) occurs at $p = \frac{4n-1}{4n}$. Except for small values of n (n = 2 and 3 say) the parent offspring and full sib curves are essentially identical, though the latter are slightly higher. For a large number of loci in the interacting set, the correlations are only slightly less than one-half except in the immediate neighborhood of

$$p = \frac{d + n - \frac{1}{2}}{2n - 1}$$

4. Bias in the Estimate of Additive Genetic Variance.

The additive genetic variance is frequently estimated by twice the parent offspring covariance or twice the full sib covariance. The additive genetic variance is always overestimated more by the full sib procedure than by the parent offspring procedure. The relationships between percentage bias and the frequency of the favorable allele for the various models are shown in graphs 2a - 2g. In the case of the additive model with dominance the parent offspring procedure is unbiased. The bias from the full sib procedure is shown in graph 2a. The bias becomes serious as the degree of dominance approaches and becomes greater than one. When $a \geq 1$, the bias is infinite at $p = \frac{1+a}{2a}$, since the additive genetic variance is zero at this value of p.

Complementary model (Graphs 2b, parent offspring; 2c, full sib). The bias for the parent offspring procedure is small when $p > 0.3$, but bias for the full sib procedure is only small when p is close to 0.5.

Duplicate factor model (Graph 2d, parent offspring; 2c, full sib). The bias for the parent offspring and full sib procedures is only small when $p < 0.15$.

Multiplicative model with complete dominance. The parent offspring procedure results in negligible bias (of the order of 0.3 per cent) for the cases examined. The full sib curves closely approximate the curve for the additive model with complete dominance.

Optimum number model (Graphs 2f, 2g). The additive genetic variance is zero at

$$p = \frac{d + n - \frac{1}{2}}{2n-1}$$

and hence the bias becomes infinite in the immediate neighborhood of this value of p. The bias from the full sib procedure is slightly higher than the bias from the parent offspring procedure.

SUMMARY

Parent offspring and full sib correlations are derived for a random mating population for symmetrical models assuming that the frequency of the more favorable allele is the same at all loci, but not necessarily one-half. A symmetrical model is one in which genotypic value is a function of the number of (--) loci, the number of (+-) loci, and the number (++) of loci only. The bias in the estimate of the additive genetic variance by twice the parent offspring covariance or twice the full sib covariance was examined. Special attention was accorded the following classical gene models: complementary, duplicate factor, multiplicative, and optimum number.

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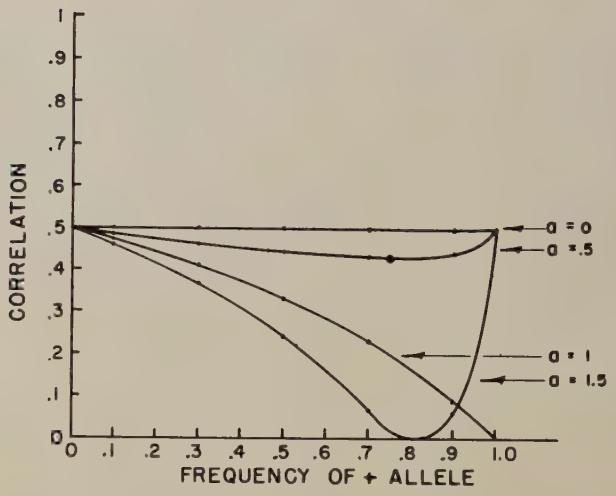
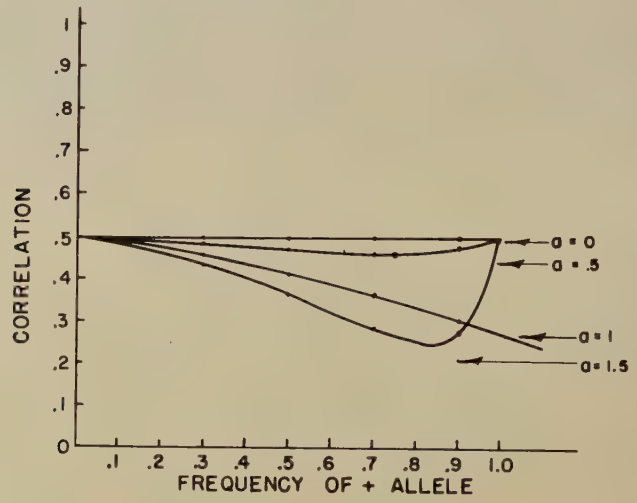
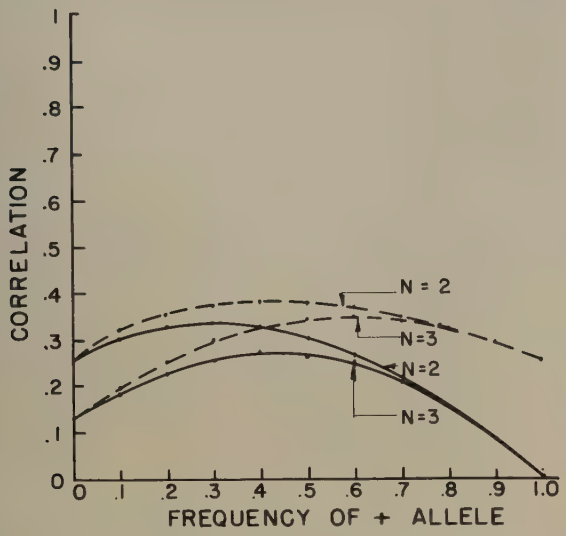


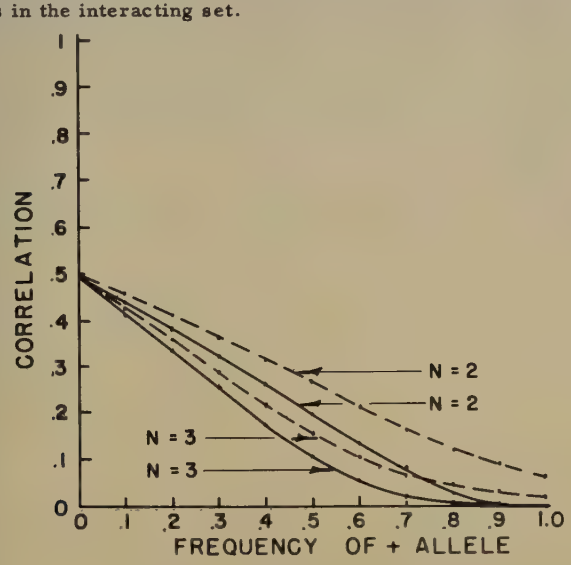
Graph 1a. Parent offspring correlations for the additive model with differing degrees of dominance. Curves for the multiplicative model with complete dominance for the cases b = e = 1.06, n = 20; b = e = 1.1 and 1.4, n = 2 and 3 are essentially identical to the curve for the additive model with complete dominance.



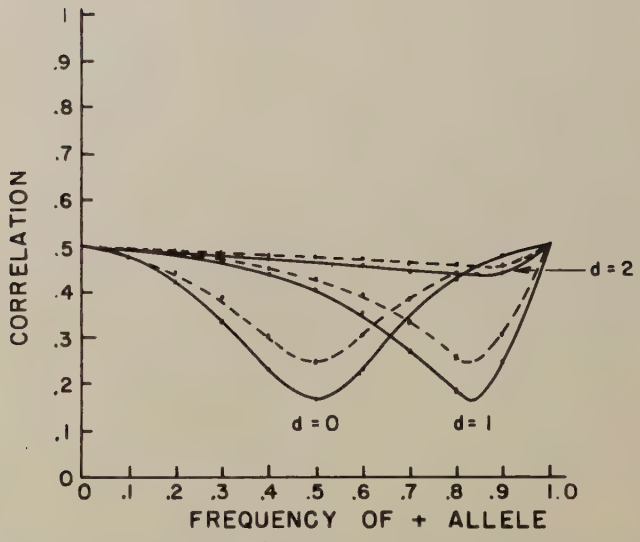
Graph 1b. Full sib correlations for the additive model with differing degrees of dominance. The curve for complete dominance is essentially identical to the curves for the multiplicative model with complete dominance for the cases considered.



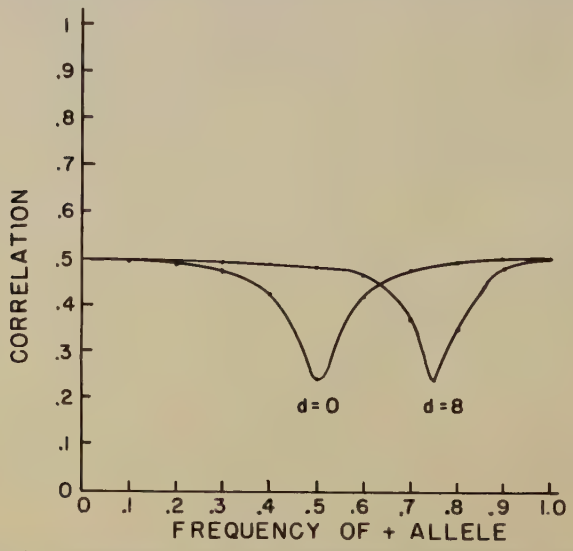
Graph 1c. Parent offspring (solid lines) and full sib (dotted lines) correlations for the complementary model, with two and three pairs of genes in the interacting set.



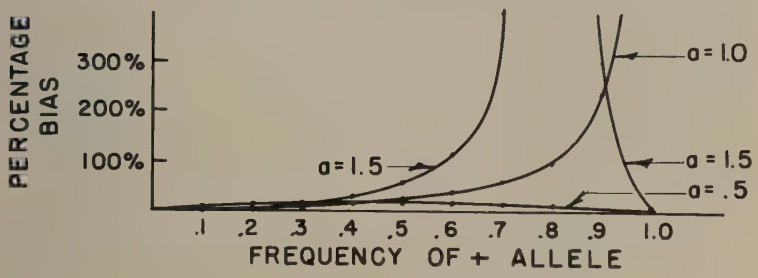
Graph 1d. Parent offspring (solid lines) and full sib (dotted lines) correlations for the duplicate factor model with two and three pairs of genes in the interacting set.



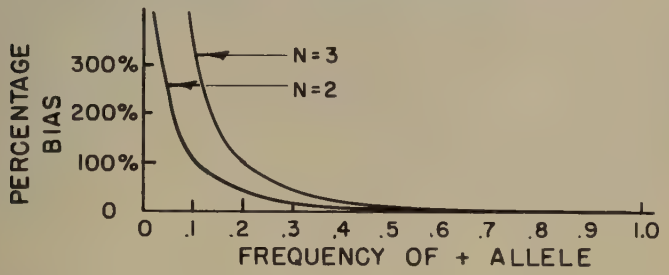
Graph 1e. Parent offspring (solid lines) and full sib (dotted lines) correlations for the optimum number model with two pairs of genes in the interacting set. The optimum number of plus genes is n + d.



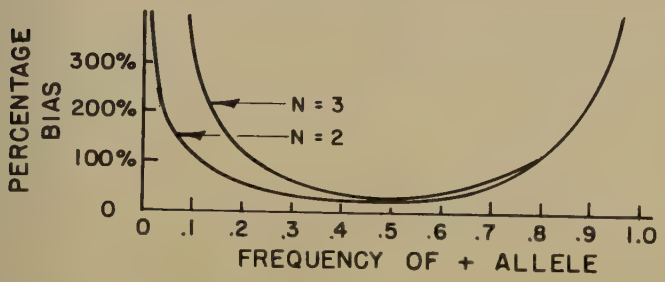
Graph 1f. Parent offspring correlations for the optimum number model with 16 pairs of genes in the interacting set. The full sib correlations are essentially the same, though very slightly higher.



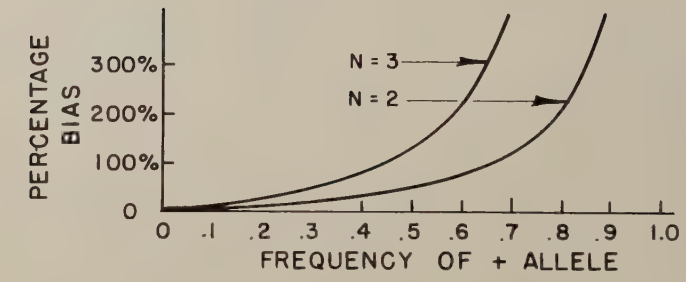
Graph 2a. Percentage bias in the estimate of the additive genetic variance by twice the full sib covariance for the additive model with varying degrees of dominance. Curves for the multiplicative model with complete dominance for the cases b = e = 1.06, n = 20; b = e = 1.1 and 1.4, n = 2 and 3 are essentially identical to the curve for the additive model with complete dominance.



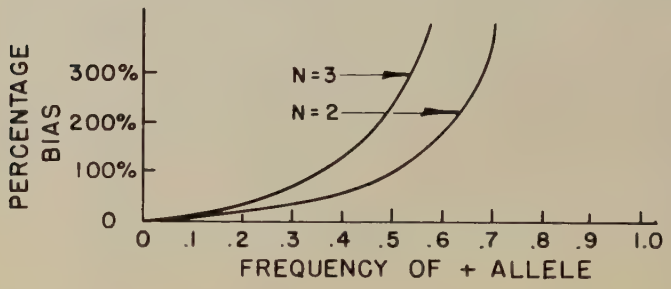
Graph 2b. Percentage bias in the estimate of the additive genetic variance by twice the parent offspring covariance for the complementary model with two and three pairs of genes in the interacting set.



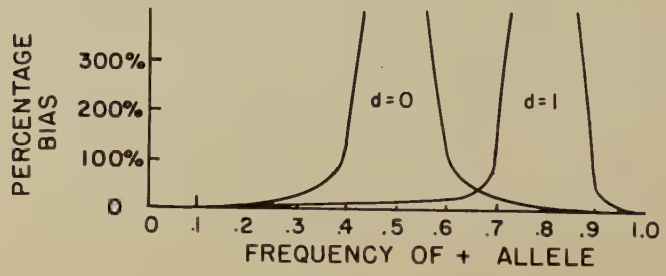
Graph 2c. Percentage bias in the estimate of the additive genetic variance by twice the full sib covariance for the complementary model with two and three pairs of genes in the interacting set.



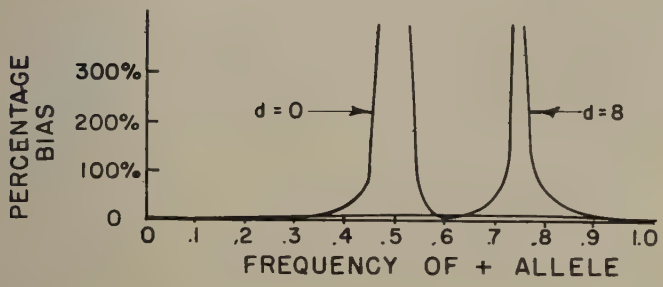
Graph 2d. Percentage bias in the estimate of the additive genetic variance by twice the parent offspring covariance of the duplicate factor model with two and three pairs of genes in the interacting set.



Graph 2e. Percentage bias in the estimate of the additive genetic variance by twice the full sib covariance for the duplicate factor model with two and three pairs of genes in the interacting set.



Graph 2f. Percentage bias in the estimate of the additive genetic variance by twice the parent offspring covariance for the optimum number model with two pairs of genes in the interacting set.



Graph 2g. Percentage bias in the estimate of the additive genetic variance by twice the parent offspring covariance for the optimum number model with sixteen pairs of genes in the interacting set.

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THE COMPONENTS OF VARIANCE IN SYMMETRICAL RANDOM MATING POPULATIONS WITH THE FREQUENCY OF THE MORE FAVORABLE ALLELE THE SAME AT ALL LOCI[1]

Theodore W. Horner[2]

INTRODUCTION

Kempthorne (1954) solved the general problem of the partition of genotypic variance and the correlation among non-inbred relatives in random mating populations. These results were applied (Horner and Kempthorne, 1955) to the case of random mating populations for which the genotypic value of a genotype could be expressed as a function of the number of nulliplex (--), the number of simplex (+-), and the number of duplex (++) loci, such a relationship of a genotypic value to genotype being referred to as a symmetrical model. It was assumed that there was normal diploid behavior at meiosis, no linkage, two alleles per locus, and that gene frequency was one-half at all loci. Particular attention was paid to the classical gene models; complementary, duplicate factor, multiplicative, and optimum number. In the present paper, the assumption that gene frequency is one-half at all loci is relaxed to the assumption that the frequency of the + allele is the same at all loci, say p_1.

It is worthwhile to consider results under this new assumption, since selection pressure operating upon genotypes, whose values are given by a symmetrical model, would probably lend to equalize the frequency of the + gene at all loci, the common value not necessarily being one-half. These results will provide a starting point for the examination of the effects of selection upon genotypes whose values are given by a symmetrical model.

Components of genotypic variance. Following the notation of Horner and Kempthorne, 1955, we will let $\sigma^2_{A^{t_a}D^{t_d}}$ symbolize the component which has A as a subscript t_a times and D as a subscript t_d times. In the case of symmetrical models under the new assumption,[3]

$$\sigma^2_{A^{t_a}D^{t_d}} = \frac{n!}{t_a!t_d!(n-t_a-t_d)!}(8p_0p_1)^{t_a}(4p_0p_1)^{2t_d}(EY^*)^2$$

[1]Journal Paper No. J-2986 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1285.

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[3]The derivation of this formula in mimeographed form is available upon request.

where

$$Y^* = (-1)^{\lambda_{010}+\lambda_{011}}(-1)^{\lambda_{101}+\lambda_{110}}\left[(A_0A_0)^{\sum_1^3\lambda_{i00}}(A_0A_1)^{\sum_1^3\lambda_{i01}}(A_1A_0)^{\sum_1^3\lambda_{i10}}(A_1A_1)^{\sum_1^3\lambda_{i11}}\right]$$

and the genotype in the brackets is to be replaced by its genotypic value. This value is a function of the number $(=\sum_1^3\lambda_{i00})$ of (--) loci, the number $(=\sum_1^3\lambda_{i01}+\sum_1^3\lambda_{i10})$ of (+-) loci and the number $(=\sum_1^3\lambda_{i11})$ of (++) loci. The frequencies of the + and - alleles are p_1 and p_0. The λ_{ijk} have the joint distribution

$$f\{\lambda_{ijk}\} = \prod_{i=1}^{3}\left[\frac{\theta_i!}{\prod_{j,k=0}^{1}\lambda_{ijk}!}\prod_{j,k=0}^{1}\Delta_{ijk}^{\lambda_{ijk}}\right]$$

where

$$\theta_1 = t_a \qquad \theta_2 = t_d \qquad \theta_3 = n - t_a - t_d$$

$$\Delta_{100} = (p_0)/2 \qquad \Delta_{200} = \tfrac{1}{4} \qquad \Delta_{300} = p_0^2$$

$$\Delta_{101} = (p_1)/2 \qquad \Delta_{201} = \tfrac{1}{4} \qquad \Delta_{301} = p_0p_1$$

$$\Delta_{110} = (p_0)/2 \qquad \Delta_{210} = \tfrac{1}{4} \qquad \Delta_{310} = p_1p_0$$

$$\Delta_{100} = (p_1)/2 \qquad \Delta_{211} = \tfrac{1}{4} \qquad \Delta_{311} = p_1^2$$

Gene models. The mathematical representation of these models is described in more detail by Horner and Kempthorne (1955). They are summarized in Table I with the numbers of (--), (+-), and (++) loci being represented by y_0, y_1, and y_2, respectively.

Table I. Genotypic Models

Model	Representation
Complementary	0^{y_0}
Duplicate factor	$1 - 0^{y_1+y_2}$
Multiplicative	$e^{y_1}b^{y_2}$
Optimum number	$-(d + y_0 - y_2)^2$

Example of the evaluation of EY*. In the case of the complementary model

$$Y^* = (-1)^{\lambda_{010}+\lambda_{011}}{}_{(-1)}{}^{\lambda_{101}} + \lambda_{110}{}_{0}{}^{y_0}$$

$$= (-1)^{\lambda_{010} + \lambda_{011}}{}_{(-1)}{}^{\lambda_{101}+\lambda_{110}}{}_{1}{}^{\sum_{1}^{3}(\lambda_{i01} + \lambda_{i10} + \lambda_{i11})} \; {}_{0}{}^{\sum_{1}^{3}\lambda_{i00}}$$

and

$$EY^* = \left(- \frac{p_0}{2} \right)^{t_a} \left(- \frac{1}{4} \right)^{t_d} (1-p_0^2)^{n-t_a-t_d}$$

The formulas for $\sigma^2_{A^{t_a} D^{t_d}}$ in the case of the complementary model is shown in Table II along with formulas for other models.

Table II. Formulae for Components of Genotypic Variance

Model	Formula
Complementary $\frac{n}{t_a!t_d!(n-t_a-t_d)!}$	$(2p_1p_0{}^3)^{t_a}(p_0p_1)^{2t_d}(1-p_0^2)^{2(n-t_a-t_d)}$
Duplicate factor $\frac{n!}{t_a!t_d!(n-t_a-t_d)!}$	$\left(\frac{2p_1}{p_0}\right)^{t_a}\left(\frac{p_1}{p_0}\right)^{2t_d}\left[{}_{0}{}^{t_a+t_d} - p_0{}^{2n}\right]^2$
Multiplicative $\frac{n!}{t_a!t_d!(n-t_a-t_d)!}$	$(2p_0p_1)^{t_a}\left[p_0 + (p_1-p_0)e - p_1b\right]^{2t_a}$
	$\times (p_0p_1)^{2t_d}(1-2e+b)^{2t_d}(p_0^2 + 2p_0p_1e + p_1^2 b)^{2(n-t_a-t_d)}$
Optimum Number	$\sigma_A^2 = 2np_0p_1\left[2d + (p_0-p_1)(2n-1)\right]^2$
	$\sigma_D^2 = 4np_0^2p_1^2 \qquad \sigma_{AA}^2 = 8n(n-1)p_0^2p_1^2$
	Higher components are zero.

Table III. Components of Genotypic Variance Expressed as Fractions of the Total Genotypic Variance.

	Frequency of + gene			
.1	.3	.5	.7	.9
	Complementary Model (n = 2)			
Component				
A	.30	.56	.57	.44	.18
D	.02	.12	.29	.51	.81
AA	.61	.22	.06	.01	.00
AD	.07	.09	.06	.02	.00
DD	.00	.01	.02	.01	.00
	Complementary Model (n = 3)			
A	.08	.36	.49	.42	.18
D	.00	.08	.24	.49	.81
AA	.34	.28	.11	.02	.00
AD	.04	.12	.10	.04	.00
DD	.00	.01	.03	.03	.00
AAA	.45	.08	.01	.00	.00
AAD	.08	.05	.01	.00	.00
ADD	.00	.01	.01	.00	.00
DDD	.00	.00	.00	.00	.00
	Duplicate Factor Model (n = 2)			
A	.85	.54	.27	.08	.00
D	.05	.12	.13	.09	.02
AA	.09	.23	.27	.18	.03
AD	.01	.10	.27	.41	.29
DD	.00	.01	.07	.24	.66
	Duplicate Factor Model (n = 3)			
A	.75	.34	.10	.01	.00
D	.04	.07	.05	.01	.00
AA	.17	.30	.19	.05	.00
AD	.02	.13	.19	.11	.00
DD	.00	.01	.05	.07	.02
AAA	.01	.08	.13	.07	.01
AAD	.00	.05	.19	.26	.08
ADD	.00	.01	.10	.30	.35
DDD	.00	.00	.01	.12	.53
	Multiplicative Model (b = 1.1, n = 2)			
A	.95	.82	.67	.46	.18
D	.05	.18	.33	.54	.82
Others	.00	.00	.00	.00	.00
	Multiplicative Model (b = 1.4, n = 2)			
A	.94	.81	.67	.46	.18
D	.05	.17	.33	.54	.82
Others	.01	.01	.00	.00	.00
	Multiplicative Model (b = 1.1, n = 3)			
A	.95	.82	.67	.46	.18
DD	.05	.18	.33	.54	.82
Others	.00	.00	.00	.00	.00

Table III. continued

Model		Component	Frequency of + gene .1	.3	.5	.7	.9
			Multiplicative Model (b = 1.4, n = 3)				
		A	.93	.80	.65	.46	.18
		D	.05	.17	.33	.53	.82
		AA	.02	.02	.01	.00	.00
		Others	.00	.00	.00	.00	.00
			Multiplicative Model (b = 1.06, n = 20)				
		A	.94	.82	.66	.46	.18
		D	.05	.18	.33	.54	.82
		Others	.00	.00	.00	.00	.00
			Optimum Number Model				
n	d						
2	0	A	.91	.53	.00	.53	.91
		D	.03	.16	.33	.16	.03
		AA	.06	.31	.67	.31	.06
	1	A	.97	.89	.73	.34	.23
		D	.01	.04	.09	.22	.26
		AA	.02	.07	.18	.44	.51
	2	A	.99	.96	.91	.86	.83
		D	.00	.01	.03	.05	.06
		AA	.01	.03	.06	.09	.12
4	0	A	.96	.73	.00	.73	.96
		D	.01	.04	.14	.04	.01
		AA	.03	.23	.86	.23	.03
	2	A	.99	.94	.82	.33	.67
		D	.00	.01	.03	.10	.05
		AA	.01	.05	.15	.58	.28
	4	A	.99	.98	.95	.90	.82
		D	.00	.00	.01	.01	.03
		AA	.01	.02	.04	.08	.15
16	0	A	.99	.92	.00	.92	.99
		D	.00	.00	.03	.00	.00
		AA	.01	.08	.97	.08	.01
	8	A	1.00	.98	.94	.50	.93
		D	.00	.00	.00	.02	.00
		AA	.00	.02	.06	.49	.07
	16	A	1.00	.99	.99	.97	.90
		D	.00	.00	.00	.00	.00
		AA	.00	.01	.01	.03	.09

Component values in special cases. The components of genotypic variance are expressed as fractions of the total genotypic variance in Table III for selected cases. For example, when gene frequency is $p_1 = 0.5$, the additive component constitutes 57 per cent of the total genotypic variance for the complementary model which involves two loci in the interacting set.

Complementary model. An examination of Table III for the case n = 2 shows that the additive variance varies from 18 to 57 per cent of the total genotypic variance, which is to be denoted hereafter as σ^2_G. The highest percentages are obtained for the intermediate gene frequencies. The dominance variance increases from 2 per cent of $\sigma_G{}^2$ at $p_1 = 0.1$ to 18 per cent at $p_1 = 0.9$. The additive x additive fraction is quite large at low gene frequencies (61 per cent at $p_1 = 1$), but rapidly diminishes as gene frequency increases (6 per cent at $p_1 = 0.5$). The additive x dominance fraction has a maximum of 9 per cent in Table III at $p_1 = 0.3$, while the dominance x dominance fraction never exceeds 2 per cent. In general, the interaction components become negligible for gene frequencies larger than 0.5. A similar pattern holds for three loci in the interacting set. Again the interaction components are negligible for $p_1 > 0.5$. The dominance fraction which is small at low gene frequencies rises to 81 per cent at $p_1 = 0.9$. The additive fraction is 8 per cent at $p_1 = 0.1$, rises to 49 per cent at $p_1 = 0.5$, and drops to 18 per cent at $p_1 = 0.9$.

It is of some interest to examine the situation when the number of loci, which is denoted by n, increases indefinitely.

In the case of the complementary model, the population mean is $(1-p_0{}^2)^n$. It seems reasonable to consider the case when this mean stays constant at k say, n increases and consequently p_0 increases.

Under these circumstances

$$(1-p_0{}^2)^n = k$$

$$p_0{}^2 = 1-k^{1/n} \quad .$$

It is clear that $p_0{}^2$ tends to zero and p_1 tends to unity, so that all the components of genotypic variance tend to zero. The total number of components of course increases in such a way that the total genotypic variance is constant and equal to $k(1-k)$.

Duplicate factor model. The additive fraction is largest at $p_1 = 0.1$, being 85 per cent for n = 2, and 75 per cent for n = 3, but then rapidly diminishes toward zero. The dominance fraction has a maximum of 13 per cent at $p_1 = 0.5$ and n = 2. The interaction components, though quite small at low gene frequencies, together constitute the major portion of σ^2_G at the higher gene frequencies. For example, for n = 3 and $p_1 = 0.9$, $\sigma_{DDD}{}^2$ and $\sigma_{ADD}{}^2$ are respectively, 53 per cent and 35 per cent of σ^2_G.

In the case of the duplicate factor model, the mean is equal to $(1-p_0^2{}^n)$ equals k say. Hence

$$p_0 = (1-k)^{1/2n}$$

so as n gets large again p_0 tends to unity, p_1 tends to zero and all components tend to zero, the total genotypic variance being again equal to $k(1-k)$.

Multiplicative model. Results can be illustrated for this case only by choosing values for b and e. The illustrative cases of Table III are those considered by Horner (1952), i.e., (i) b = e = 1.1, (ii) b = e = 1.4 and an additional case (iii) b = e = 1.06. This latter value was selected by supposing that the range in bushels per acre for a certain variety of corn was 96 to 30 and that twenty pairs of multiplicative genes with complete dominance were responsible for this range. The ratio of the largest to the smallest genotypic value would be then $n^{20} = 3.2$, which yields a value of b = 1.06.

This model is unusual in that the interaction components are negligible. Further, for a given gene frequency there is a remarkable consistency of σ^2_A (and likewise σ^2_D) for all values of b and n in Table III. The additive component constitutes 95 per cent of σ^2_G at $p_1 = 0.1$, but drops to 18 per cent of σ^2_G at $p_1 = 0.9$. The dominance fraction rises from 5 per cent at $p_1 = 0.1$ to 82 per cent of σ^2_G at $p_1 = 0.9$.

To examine what happens for the multiplicative model as the number of loci gets large, we consider the special case when b is equal to e^2, i.e., there is no dominance on the logarithmic scale. In this case, the mean of the population is

$$(p_0^2 + 2p_0p_1\, e + p_1^2\, b)^n = (p^2 + 2p_0p_1e + p_1^2\, e^2)^n = (p_0 + p_1e)^{2n} = \mu \text{ say,}$$

and the total variance is

$$(p_0^2 + 2p_0p_1\, e^2 + p_1^2\, b^2)^n - \mu^2 = (p_0^2 + 2p_0p_1e^2 + p_1^2e^4)^n - \mu^2$$

$$= (p_0 + p_1e^2)^{2n} - \mu^2 \quad .$$

The square of the coefficient of variation is therefore

$$\left(\frac{p_0 + p_1e^2}{(p_0 + p_1e)^2}\right)^{2n} - 1 \quad .$$

Now $p_0 + p_1e^2 = (p_0 + p_1e)^2 + p_0p_1(1-e)^2$ so the square of the coefficient of variation is

$$\left[1 + \frac{p_0p_1(1-e)^2}{(p_0 + p_1e)^2}\right]^{2n} - 1 \quad .$$

The additive variance under the postulated circumstances is equal to

$$\sigma^2_A = 2np_0p_1(1-e)^2\ (p_0 + p_1e)^{4n-2}$$

so

$$\frac{\sigma^2_A}{\mu^2} = \frac{2np_0p_1(1-e)^2}{(p_0+p_1e)^2} \quad .$$

Hence

$$\frac{\sigma^2_A}{\sigma^2_G} = \frac{2n\delta}{(1+\delta)^{2n}-1} \quad , \text{ where } \delta = \frac{p_0 p_1 (1-e)^2}{(p_0+p_1 e)^2} \quad .$$

If now we let n get large, keeping the coefficient of variation equal to $\sqrt{\lambda}$ then

$$(1+\delta)^{2n} - 1 = \lambda$$

$$(1+\delta)^{2n} = \lambda + 1 = e^x, \text{ say}$$

$$1 + \delta = e^{x/2n} = 1 + \frac{x}{2n}$$

so

$$\delta = \frac{x}{2n} \quad \text{and} \quad \frac{\sigma^2_A}{\sigma^2_G} \rightarrow \frac{x}{\lambda} = \frac{\log(\lambda + 1)}{\lambda} \quad .$$

Here then we have a relationship between the proportion of additive variance and the square of the coefficient of variation, if the model is strictly multiplicative there is no dominance on the log scale and the number of loci is large. For coefficients of variation between 0.1 and 0.9 inclusive and moving by tenths, we have

$$\frac{\sigma^2_A}{\sigma^2_G} = .995, \ .98, \ .96, \ .93 \ , \ .89, \ .85, \ 81, \ .77, \text{ and } .73.$$

It is curious that the relationship does not depend on gene frequency.

Optimum number model. The total genotypic variance is made up of only three parts σ^2_A, σ^2_D, and σ^2_{AA}. The additive fraction with respect to gene frequency achieves a minimum at a gene frequency of one-half when the optimum number of plus genes is half the maximum number; i.e., when d is close to zero. As d increases, this minimum point is shifted toward the higher frequencies of the + gene. The dominance fraction becomes small as n increases and thus the additive x additive fraction becomes the complement of the additive fraction. For the higher values of n, the additive fraction is quite large (90 per cent and above) except in the immediate neighborhood of its minimum value with respect to gene frequency.

The population mean, $\bar{Y}$ say, is $\bar{Y} = -\left[d + n(p_0 - p_1)\right]^2 - 2np_0p_1$, which is a quadratic in p_1 having a maximum within the range $0 \leq p_1 \leq 1$ at

$$p_1 = \begin{cases} \dfrac{d + n - \frac{1}{2}}{2n - 1} & \text{for } 0 \leq d \leq (n - 1) \\ 1 \text{ for } d = n. \end{cases}$$

The maximum is

$$\text{Max } \bar{Y} = \begin{cases} -\left[\frac{n}{2} - \frac{d^2}{2n-1}\right] & \text{for } 0 \leq d \leq (n-1) \\ 0 \text{ for } d = n \end{cases}$$

Since genotypic value, say Y, is $Y = -(d+y_0-y_2)^2$, the maximum and minimum values for Y are zero and $-(d+n)^2$. It follows that

$$\frac{\text{Max } \bar{Y} - \text{Min } Y}{\text{Max } Y - \text{Min } Y} = 1 - \frac{\frac{n}{2} - \frac{d^2}{2n-1}}{(d+n)^2}$$

which equals $1 - \frac{1}{2n}$ for $d = 0$ and is between $1 - \frac{1}{2n}$ and 1 for $0 < d \leq n$.

Table IV. Total Genotypic Variances as Fractions of the Total Genotypic Variance for a Gene Frequency of One-half

		Frequency of + gene				
		.1	.3	.5	.7	.9
Model	$\frac{n}{2}$					
Complementary	2	.14	.78	1	.58	.08
	3	.03	.47	1	.76	.12
Duplicate Factor	2	3.85	3.11	1	.14	.00
	3	16.20	6.75	1	.05	.00
Multiplicative						
b = 1.1	2	.74	1.27	1	.45	.06
b = 1.4	2	.56	1.15	1	.48	.06
b = 1.1	3	.67	1.22	1	.46	.06
b = 1.4	3	.39	.99	1	.52	.07
b = 1.06	20	.24	.79	1	.62	.09
Optimum Nunber						
n d						
2 0		1.51	1.51	1	1.51	1.51
1		1.30	1.76	1	.29	.05
2		.85	1.36	1	.44	.06
4 0		3.36	2.59	1	2.59	3.36
2		1.72	2.12	1	.19	.07
4		.99	1.49	1	.37	.03
16 0		14.40	9.04	1	9.04	14.41
8		2.21	2.54	1	.08	.11
16		1.12	1.61	1	.32	.02

Thus when n is large, the maximum value of the population mean relative to the genotypic range of values is at the upper end of this range. It should be noted, however, that the poorer genotypes may not be viable and hence the maximum value of the population mean may not be close, relatively speaking, to the upper end of the biological scale.

It is easily seen that the additive variance is zero when $p_1 = \frac{d+n-\frac{1}{2}}{2n-1}$ and when $p_1 = 1$, and thus this variance is zero when the population mean is at its maximum. Since σ^2_A is of the order n^3, except in the immediate neighborhood of $p_1 = \frac{d+n-\frac{1}{2}}{2n-1}$, while σ^2_D and σ^2_{AA} are of the order of n and n^2, the genotypic variance is essentially additive for large n.

Change in genotypic variance with change in gene frequency. In Table IV the total genotypic variances are expressed as fractions of the total genotypic variance for $p_1 = 0.5$. Thus, in the case of the complementary model for n = 2, σ^2_G for $p_1 = 0.7$ is 58 per cent of σ^2_G for $p_1 = 0.5$.

For the complementary model the total genotypic variance is greatest for a gene frequency of one-half. For the duplicate factor model, σ^2_G is greatest for the smaller gene frequencies and least for the higher gene frequencies. The multiplicative model follows a pattern similar to that of the complementary model except in the neighborhood of $p_1 = 0.3$, where σ^2_G may be larger than it is at 0.5. In the case of the optimum number model, σ^2_G may have values smaller than its value at $p_1 = 0.5$ for higher values of p_1 and/or d. Otherwise the converse generally holds.

SUMMARY

A general solution to the problem of the partition of genotypic variance in random mating populations was given by Kempthorne in 1954. Horner and Kempthorne (1955) applied these results to the case of random mating populations for which the genotypic value can be expressed as a function of the number of nultiplex (--), the number of simplex (+-), and the number of duplex (++) loci, such a relationship of a genotypic value to genotype being referred to as a symmetrical model. In that paper gene frequency was assumed to be one-half at all loci. In the present paper this assumption was relaxed to the assumption that the frequency of the +allele is the same at all loci. The following classical gene models were given particular attention and the results discussed for each: complementary, duplicate factor, multiplicative, and optimum number.

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MEASUREMENTS OF THE UNSPORULATED OOCYSTS OF EIMERIA ACERVULINA, E. MAXIMA, E. TENELLA, AND E. MITIS; COCCIDIAN PARASITES OF THE COMMON FOWL[1]

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Measurements of the oocysts of Eimeria brunetti and E. necatrix have recently been reported (1, 2). The present series of measurements on E. acervulina, E. maxima, E. tenella, and E. mitis are not so extensive as those on the other two species, but it would not be possible for us to expand them in the near future. The oocysts of E. praecox and E. hagani were not available for measuring.

Tyzzer (1929) represents the size of the fresh oocysts of E. acervulina to be as follows: average 19.5 x 14.3 μ ; maximum, 20.2 x 16.3 μ ; minimum, 17.7 x 13.7 ; while Edgar (1955) records a mean size of 18.3 x 14.6 μ . Tyzzer presents, for the average size of E. maxima 29.3 x 22.6 μ ; 42.5 x 29.8 μ for the maximum, and 21.4 x 16.5 μ for the minimum; Edgar, 30.5 x 20.7 μ for the mean. Tyzzer records the size of E. mitis as follows: average, 16.2 x 15.5 μ ; maximum, 19.6 x 17.0 μ ; minimum, 14.3 x 13.0 μ ; while Edgar found the mean size to be 16.2 x 16.0 μ . Tyzzer's tabulations show the dimensions of E. tenella to be as follows: Average size, 22.6 x 19.0 μ ; maximum, 26.1 x 22.8 μ ; minimum, 19.6 x 16.3 μ ; Edgar's are 22.0 x 19.0 μ for the mean size. Fish (1931) found for E. tenella an over-all range of 16.1 - 29.2 μ for length and 11.8 - 25.9 μ for width, and observed marked bird-to-bird and day-to-day variations in average size.

MATERIALS AND METHODS

One-third to one-half grown Hampshire Reds were employed for hosts. Pure cultures, i.e., oocysts of one species unmixed with those of another species, were obtained by various expedients from infected chickens on near-by farms, and were passed through and studied in several series of previously coccidia-free chickens in order to confirm their separate specific identities. The doses of infective oocysts administered were of such moderate proportions as to produce subclinical coccidiosis. Methods of collecting, measuring and analyzing the data have been described in the aforementioned papers.

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Table 1. Statistical data derived from the measurements of the unsporulated oocysts of Eimeria acervulina, E. maxima, E. tenella and E. mitis.

Days of p.p.	Total Oocysts	Length			Width			Mean S.I.
		Range (μ)	Mean (μ)	S.D. (μ)	Range (μ)	Mean (μ)	S.D. (μ)	
Eimeria acervulina (3 chickens)								
4-10	700	12.0-22.7	16.58	±1.63	9.2-17.5	13.12	±1.23	1.26
4-12	825	11.7-21.2	16.29	±1.50	9.9-16.7	12.97	±1.19	1.26
4-20	1652	12.0-21.2	16.34	±1.46	9.2-17.0	12.82	±1.11	1.27
Average		(12.96-20.12)	16.40	±1.53	(10.51-15.33)	12.97	±1.18	1.26
Eimeria maxima (1 chicken)								
6	50	26.9-35.4	31.84	±1.44	20.9-25.1	22.78	±0.86	1.40
Eimeria tenella (1 chicken)								
7-14	660	14.2-31.2 (17.78-27.76)	22.96	±2.20	9.5-24.8 (13.93-22.60)	19.16	±1.69	1.20
Eimeria mitis (2 chickens)								
5-7	300	9.9-21.5	16.79	±1.87	8.5-17.7	13.28	±1.41	1.26
6	100	11.7-18.1	14.77	±1.36	10.6-15.9	13.50	±1.13	1.09
Average		(12.25-19.59)	15.78	±1.62	(10.34-16.22)	13.39	±1.27	1.18

RESULTS

In Table 1 are recorded the range, mean, and standard error (S.D.) for length and width of the unsporulated oocysts passed during the patent period (p.p.) of the infections, as well as the mean shape-index (S.I.), or length/width. The plan was to measure 100 oocysts on each bird-day, but it was not always possible to find that many.

Eimeria acervulina (Figs. 1, 2)

There were three infections of this species with patent periods of 7, 9, and 17 days, respectively. The over-all range in size is 11.7 - 22.7 x 9.2 - 17.5 μ, and the average range for the 33 bird-days is 12.96 - 20.12 x 10.51 - 15.33 μ. The means for the 33 bird-days range from 15.35 - 17.47 μ for length and from 12.31 - 14.08 μ for width. The average mean size, i.e., the average of the mean of the daily mean sizes for each bird, is, with average S.D., 16.40 ± 1.53 x 12.97 ± 1.18 μ. The over-all range of S.I. was 1.02 - 1.63; and the average mean S.I. of the three infections was 1.26, which is close to Edgar's indicated 1.25, though below Tyzzer's 1.36. When the 100 S.I.s for each of the bird-days were grouped, approximately one-third of them fell into the 1.23 - 1.32 interval.

There is no immediate explanation for the difference between our average measurements and those of Tyzzer and those of Edgar. We observed individual oocysts whose size exceeded the maximum designated by Tyzzer, but our range from them downwards to the smallest was much greater. Three possible explanations might be, 1) that ours was a strain with a greater range downward from the maximum size, 2) that there was a potent host-influence operating, or 3) that our infective dosages were greater than those of Tyzzer and Edgar.

Eimeria maxima

For some reason it was very difficult to maintain this species (unmixed with other species of coccidia) in our experimental infections. Certain hosts seemed to possess an almost complete immunity, while others yielded only a very small return compared to the numbers fed. Sufficient numbers for our purposes appeared, in one chicken only, on the sixth day. These ranged in length from 26.9 - 35.4 μ and in width from 20.9 - 25.1 μ. When grouped, the distribution of lengths is as follows: 26.1 - 28.0 μ, 1; 28.1 - 30.0 μ, 6; 30.1 - 32.0 μ, 23; 32.1 - 34.0 μ, 19; 34.1 - 36 μ, 1. The distribution of widths: 20.1 - 22.0 μ, 10; 22.1 - 24.0 μ, 36; 24.1 - 26.0 μ, 4. Mean size, with standard deviations, was 31.84 ± 1.44 x 22.7 ± 0.83 μ. Thus, our mean size is close to Tyzzer's; and our average S.I. of 1.40 is to be compared with Tyzzer's indicated 1.30 and Edgar's indicated 1.47. Our distribution of S.I. was as follows: 1.23 - 1.27, 3; 1.28 - 1.32, 6; 1.33 - 1.37, 14; 1.38 - 1.42, 8; 1.43 - 1.47, 9; 1.48 - 1.52, 9; 1.53 - 1.57, 1.

Eimeria tenella (Figs. 3, 4)

The one infection studied has a patent period of eight days during which 600 oocysts were measured. The over-all size range is from

14.2 - 31.2 x 9.5 - 24.8 μ, one in close agreement with Fish's over-all range, but the average of the daily ranges is but 17.78 - 27.76 x 13.98 - 22.60μ. The average size, with average S.D.s, was 22.96 ± 2.20 x 19.16 ± 1.69 μ. This average size is very close to 22.87 x 18.28μ, the average daily means for Fish's bird No. 330, but out S.D.s are larger. Also, our average is close to Tyzzer's 22.6 x 19.0 and Edgar's 22.0 x 19.0 μ. Our average S.I. of 1.20 is to be compared with Tyzzer's computed 1.19, Edgar's 1.16, and Fish's over-all one of 1.25.

It is of some interest that on every day of the patent period, length and width measurements when grouped in intervals of 2.0 μ described unimodal frequency curves, though they were more or less skewed; e.g., the means of the 2 μ intervals for length and frequencies of 100 oocysts on day 11 were as follows: 19 μ, 4; 21 μ, 21; 23 μ, 44; 25 μ, 29; 27 μ, 2. Those for width; 15 μ, 1; 17 μ, 12; 19 μ, 75; 21 μ, 12. The curves for length were not always so near normal, nor were those for width always so skewed.

Eimeria mitis (Figs. 5, 6)

Two isolations were made of this species, There were enough oocysts to make measurements of the first on three days and of the second only on the sixth day. The first ranges in length from 9.9 - 21.5μ, and in width from 8.5 - 17.7 μ; average, with average S.D.s, 16.79 ± 1.87 x 13.48 ± 1.41μ. The second ranges in length from 11.7 - 18.1μ, and in width from 10.6 - 15.9 μ; mean, with S.D.s, 14.77 ± 1.36 x 13.50 ± 1.13 μ. The average S.I. of the first is 1.26; that of the second, 1.09.

It is possible that these two isolations represent either different species or morphologically different strains of the same species, because the lengths differ significantly, though the widths do not. The first corresponds closely with our isolation of E. acervulina in size and shape index, but the oocysts are broadly ellipsoidal rather than egg-shaped. Also, it is not so heavy a yielder of oocysts as is E. acervulina. Our average measurements do not check closely with those of Tyzzer and of Edgar, stated above. It is possible that there are a number of strains of this species, or that its size and S.I. are susceptible to hostal or other influences.

SUMMARY

There follows a summary of the average sizes (length x width) with average standard deviations, and of the average shape-indexes, of each of the six species of Eimeria occurring in the chicken that have been investigated by us (the figures for E. mitis representing the average of our two isolations):

E. maxima	31.84 ± 1.44 μ x 22.7 ± 0.86 μ	1.40
E. brunetti	23.40 ± 2.00 μ x 19.70 ± 1.70 μ	1.19
E. tenella	22.96 ± 2.20 μ x 19.16 ± 1.69 μ	1.20
E. necatrix	19.70 ± 1.82 μ x 16.70 ± 1.20 μ	1.18
E. acervulina	16.40 ± 1.53 μ x 12.97 ± 1.18 μ	1.26
E. mitis	15.78 ± 1.62 μ x 13.39 ± 1.27 μ	1.18

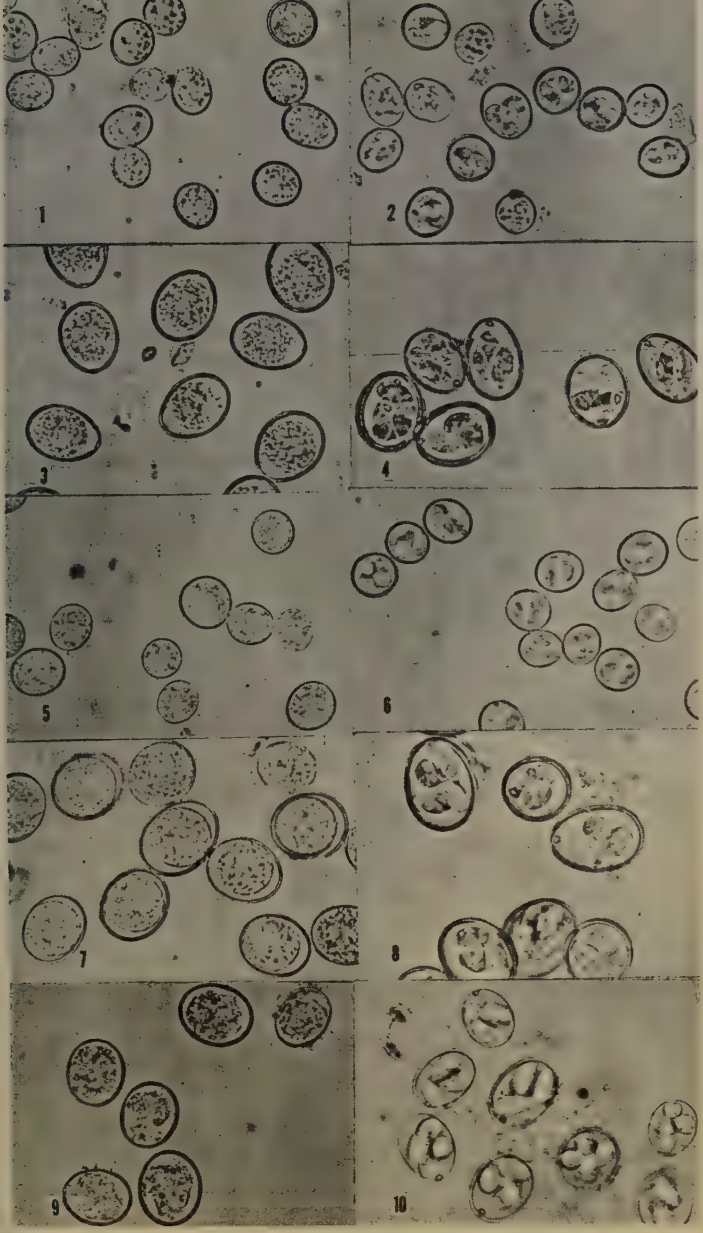

Plate 1. **The sporulated and unsporulated oocysts of five of the species of coccidia occurring naturally in chickens of Central Iowa. 1.2, Eimeria acervulina; 3,4, E. tenella; 5,6, E. mitis; 7,8, E. brunetti; 9,10, E. necatrix. X 480.**

As has been suggested above, further measurements are needed on the oocysts of E. acervulina and of E. mitis in "pure" infections, i.e., infections unmixed with those of Eimeriae other than the one under consideration. Our measurements on E. maxima, E. brunetti, and E. tenella, however, are not in actual disagreement with those of certain previous workers.

It should be emphasized that the measurements of length and of width of oocysts taken in any particular sample, when properly grouped, described unimodal curves, with rare exceptions. No bimodal curves resulted for the measurements of species reported in this paper.

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CATALOG OF EIMERIIDAE IN GENERA OCCURRING IN VERTEBRATES AND NOT REQUIRING INTERMEDIATE HOSTS

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This catalog comprises known species of the family Eimeriidae belonging to genera represented in vertebrate hosts and not requiring intermediate animal transmitters; i.e., they are filth-borne. The genera which thus qualify for inclusion are Cryptosporidium, Tyzzeria, Mantonella, Caryospora, Cyclospora, Isospora, Dorisiella, Eimeria, Wenyonella, Octosporella, Yakimovella, and Pythonella. They are treated here in the order named. The genus Mantonella, though not occurring in vertebrates, is included because of its close relationship to the other eleven and, hence, the possibility that it may eventually be found in vertebrate hosts.

The name of each species is followed by that of the describer and the bibliographic citation in parenthesis. Under the species appears the measurements of the oocysts in microns, (M) signifying mean size and (R) size range. When the measurements apply to sporocysts, it is so stated. The so-called shape-index, i.e., ratio of length to breadth, can be approximated by dividing the mean length by the mean breadth. Both the scientific name and the common name of the host are stated when known. The subgenus of the host sometimes follows the genus in parenthesis, as in Lepus (Macrotolagus) californicus. Parenthesis with quotation marks enclosing a name following the genus indicate the enclosed name was either employed by the described of the coccidium for the name of its host or has commonly been used by other workers; e.g., the combination Callithrix ("Hepale") jacchus penicillatus means that the original describer used the combination Hepale jacchus penicillatus for the host of, in this case, Isospora arctopitheci. This procedure is, of course, nomenclaturally indefensible.

Rejected names appear in the catalog, along with the valid names. Such rejected names can be detected by the nature of the remarks stating the reason for the rejection.

The catalogs of the species of genus Eimeria by Levine and Becker, 1933 (258), Hardcastle, 1943 (171), and Pellérdy, 1956 (313a), which arrived after this catalog had gone to press, and of the genus Isospora by Becker, 1934 (10) were of tremendous help in compiling this catalog.

The help of Dr. Normal D. Levine in deciding upon the proper names of certain rodents, and of Dr. C.A. Hoare in obtaining certain literature, is gratefully acknowledged.

1. CRYPTOSPORIDIUM Tyzzer, 1910 (438)

Type species: C. muris Tyzzer, 1910 (438)

C. crotali Triffitt, 1925 (434). (R) 10.0 x 10.8-11.0 x 12.5. (The possibility that this coccidium is the spore of an Isospora requires serious consideration. Vide Hoare, 1933 (184)) In Crotalus confluentus, Rattlesnake. (Reptilia: Serpentes)

C. muris Tyzzer, 1910 (437, 438). (M) 7.0 x 5.0. In stomach of Mus musculus, House Mouse. (Rodentia: Murinae)

C. parvum Tyzzer, 1912 (439). (R) 4.0-4.5 x 3.0-3.3. In small intestine of Mus musculus, House Mouse. (Rodentia: Murinae)

C. vulpis Wetzel, 1938 (452). (R) 13.0-15.2 x 8.0-9.0. (M) ca. 13.5 x 8.0. (The possibility that this coccidium is the spore of an Isospora bigemina-like coccidium requires serious consideration.) In Vulpes vulgaris, Red Fox. (Carnivora: Caninae)

2. TYZZERIA Allen, 1936 (6)

Type species: T. perniciosa Allen, 1936 (6)
Synonym: Koidzumiella Matubayasi, 1936 (278)

T. alleni Chakravarty and Basu, 1947 (70). (R) 14.5-17.3 x 9.6-11.5. In Chenicus ("Nettapus") coromandelianus, Cotton-Teal. (Aves: Anseriformes)

T. anseris Neischulz, 1947 (302). (R) 12.0-16.0 x 10.0-12.5. (M) 14.0 x 11.5. In Anser anser anser, Domestic Goose. (Aves: Anseriformes)

T. natrix (Matubayasi, 1936 (278)) Matubayasi, 1937 (279). (R) 11.7-16.1. (M) 14.4. Synonyms: Koidzumiella natrix Matubayasi, 1936 (278); Tyzzeria (Koidzumiella) natrix Matubayasi, 1937 (279). In Natrix tigrina, Japanese Water Snake. (Reptilia: Serpentes)

T. perniciosa Allen, 1936 (6). (R) 10.0-13.3 x 9.0-10.8. In Anas domesticus, Domestic Duck. (Aves: Anseriformes)

3. MANTONELLA Vincent, 1936 (443)

Type species: M. peripati Vincent, 1936 (443)
Synonym (?): Yakimovella Gousseff, 1936 (152).

(Mantonella is included here because of its close relationship to genera that occur in vertebrates.)

M. peripati Vincent, 1936 (443). (M) 30.0 x 17.0 (in P. sedgwicki); 36.0 x 17.5 (in P. moseleyi). In Peripatopsis sedgwicki and P. moseleyi, Walking Worms ("Peripatus"). (Arthropoda: Onychophora)

M. potamobii Gousseff, 1936 (152). (R) 24.5-25.9 x 11.4-12.9. In Potamobius leptodactylus, a crayfish. (Arthropoda: Crustacea)

4. CARYOSPORA Léger, 1904 (240,241)

Type species: C. simplex Léger, 1904 (240)
Synonym: Eumonospora Allen, 1933 (3)

(Léger (1904 (240)) used the spelling Karyospora in his first paper, but in the second (1904 (241)) he transliterated to Caryospora. Cf. Hoare, 1933 (184)).

C. brasiliensis Carini, 1932 (35). (R) 20.0-22.0. In Philodryas ("Chlorosoma") aestivum, "Cobra Verde". (Reptilia: Serpentes)

C. falconis Wetzel and Enigk, 1937 (454). (R) 32.0-34.0. In Falco peregrinus, "Wanderfalken". (Aves: Falconiformes)

C. gekkonis Chakravarty and Kar, 1947 (76). (M) 19.8 x 19.8. In Gecko gecko, an Indian lizard. (Reptilia: Sauria)

C. henryi (Yakimoff and Matikaschwili, 1932 (503)) Yakimoff and Matschoulsky, 1936 (512). (R) 37.0-42.0 x 30.0-35.0. Synonym: Isospora henryi Yakimoff and Matikaschwili, 1932 (503). Possible synonyms: Eumonospora tremula Allen, 1933 (5); Caryospora tremula (Allen, 1933 (5)) Hoare, 1934 (185). In Bubo bubo, Eagle-Owl; Milvus migrans, Black Kite; Falco tinnunculus and Falco subbuteo, falcons. (Aves: Strigiformes)

C. japonicum Matubayasi, 1937 (278). (R) 14.6-21.9 x 14.6-21.0. (M) 18.6 x 18.6. In Natrix tigrina, Japanese Water Snake. (Reptilia: Serpentes)

C. jararacae Carini, 1939 (52). Synonym: Caryospora jaracae Carini, 1939 (52). Lapsus. (R) 13.0-14.0 x 13.0-14.0. In Bothrops jararaca ("Lachesis lanceolatus"), "jararaca". (Reptilia: Serpentes)

C. legeri Hoare, 1933 (184). (R) 20.8-30.4 x 19.2-25.6. In Psammophis sibilans, Hissing Sand Snake. (Reptilia: Serpentes)

C. simplex Léger, 1904 (240,241). (R) 10.0 x 10.0-15.0 x 15.0. In Vipera aspis, European Asp. (Reptilia: Serpentes)

C. tremula (Allen, 1933 (3,5)) Hoare, 1934 (185). (R) 33.0-35.0 x 28.0-30.0. Synonym: Eumonospora tremula Allen, 1933 (3). Possible synonym: Caryospora henryi (Yakimoff and Matikaschwili, 1932 (503)) Yakimoff and Matschoulsky, 1936 (512). (Cf. Yakimoff and Matschoulsky, 1936 (512)) In Cathartes aura septentrionalis, Turkey Buzzard. (Aves: Falconiformes)

5. CYCLOSPORA Schneider, 1881 (392)

Type species: Cy. glomericola Schneider, 1881 (392)

C. babaulti Phisalix, 1924 (323). (M) 16.8 x 10.5. In Vipera berus, Common Viper or Adder. (Reptilia: Serpentes)

C. caryloytica Schaudinn, 1902 (389). (M) ca. 18.0 x 12.5. In Talpa europaea, European Mole; Parascalops breweri, Hairy-Tailed Mole. (Insectivora: Talpidae)

C. glomericola Schneider, 1881 (392). (R) 25.0-36.0 x 9.0-10.0. In Glomeris sp., a millipede. (Arthropoda: Diplopoda)

C. scinci Phisalix, 1924 (324). (M?) 10.5 x 7. In Scincus officinalis, Egyptian Skink. (Reptilia: Sauria)
C. tropidonoti Phisalix, 1924 (325). (M) 16.8 x 10.5. In Natrix ("Tropidonotus") natrix, Common Grass Snake. (Reptilia: Serpentes)
C. viperae Phisalix, 1923 (321, 327, 329, 332). (M) Macrogamete 16.8 x 12.6. In Vipera aspis, European Asp; Natrix ("Tropidonotus") viperinus, Viperine Snake; Coronella austriaca, Smooth Snake; Coluber scalaris, "Couleuvre à Échelons". (Reptilia: Serpentes)
C. zamensis Phisalix, 1924 (326). (M) 16.8 x 10.5. In Zamensis gemonensis var. viridiflavus. (Reptilia: Serpentes)

6. ISOSPORA Schneider, 1881 (392)

Type species: I. rara Schneider, 1881 (392)
Principal synonyms: Psorospermium Rivolta, 1878 (375) pro parte; Coccidium Leuckart, 1879 (250) pro parte; Diplospora Labbé, 1893 (213); Klossia Labbé, 1894 (217); Hyaloklossia Labbé, 1896 (220); Lucetina Henry and Leblois, 1925 (175, 176).

(The present author believes that in view of the almost general acceptance of the generic name Isospora for 2-sporocystid, 4-sporozoic Eimeriidae, and also of the confusion that would prevail for a time if Diplospora were substituted, the former name should be retained. Certain authors, however, among them Railliet (1895, (341 p. 182)) and Grasse (1953 (155, p768), adhering literally to Schneider's text, consider Isospora a form with an indefinite number of or with somewhat numerous sporozoites, and occurring only in a still undetermined species of Limax. Laveran and Mesnil (1902 (227)) prefer Isospora to Diplospora. Schneider's figure of the developed oocyst certainly does not preclude the possibility that the sporocysts were 4-sporozoic. Cf. Léger, 1898 (238), and Laveran, 1898 (225)).
I. ameïvae Carini, 1932 (36). (M) 19.0 x 16.0. In Ameiva ameiva, a New World lizard; Cnemidophorus lemniscatus, "Calango" or "Taguira", also a New World lizard. (Reptilia: Sauria)
I. americana Roudabush, 1937 (379). See I. dirumpens var. americana Roudabush, 1937.
I. arctopitheci Rodhain, 1933 (378). (M) 30.5 x 25.5. In Callithrix ("Hapale") jacchus penicillatus, a marmoset. (Primates: Anthropoidea)
I. avium (Rivolta, 1878 (375)) Railliet, 1895 (341). Nomen nudum. Synonyms: Posorospermium avium Rovolta, 1878 (375); Diplospora avium (Rivolta, 1878) Henry and Leblois, 1926 (175).
I. belli Wenyon, 1923 (449). (R) 25.0-33.0 x 12.5-16.5. Synonyms: I. hominis (Rivolta, 1878 (375)) Dobell, 1919 (103); I. bigemia var. hominis Fantham 1917 (121); I. hominis Fantham, 1917 (l.c. Magath 1935 (269)); Lucetina belli (Wenyon, 1923) Henry and Leblois, 1926 (176). In Homo sapiens, Man. (Primates: Anthropoidea)
I. bigemina (Stiles, 1891 (421) Lühe, 1906 (264). (Characteristic oocysts appear in stools fully sporulated; bigeminal with two spores squeezed together by tightly stretched, thin oocyst membrane: spores also appear in stoool singly.) (R) Small forms, 10.0-16.0 x 7.5-10.0:

large forms, 18.0-20.0 x 14.0-16.0. Synonyms: Coccidium bigeminum Stiles, 1891 (421,422); Coccidium bigeminum var. canis Railliet and Lucet, 1891 (343); Lucetina bigemina (Stiles, 1891) Henry and Leblois, 1926 (176). Possible synonym: I. hominis Railliet and Lucet, 1891 (343) Wenyon, 1923 (449). In Canis familiaris, Dog; Felis domestica, Cat; certain other carnivores. (Carnivora: Caninae and Felinae, resp.) In Homo sapiens, Man(?). Primates: Homininae)

I. bigemina var. canis Railliet and Lucet, 1891 (343). (R) (Sporocyst measurements) 12.0-15.0 x 7.0-9.0. Synonym: Coccidium bigeminum var. canis Railliet and Lucet, 1891 (343). Synonym of I. bigemina. In Canis familiaris, Dog. (Carnivora: Caninae)

I. bigemina var. canivelocis (Weidman, 1915 (448)). (R) 30.0-40.0 x 25.0-30.0. Synonyms: Coccidium bigeminum var. canivelocis Weidman, 1915 (448); Coccidium bigeminum canivelocis Hall and Wigdor, 1918 (169); Isospora canivecolis Wenyon, 1923 (449); Lucetina canivelocis Henry and Leblois, 1926 (176), lapsus; Lucetina canivelocis Sprehn and Cramer, 1931 (413). In Vulpes velox, Swift Fox, and other foxes. (Carnivora: Caninae)

I. bigemina var. cati Railliet and Lucet, 1891 (343). (R) (Sporocysts) 8.0-10.0 x 7.0-9.0. In Felis domestica, Cat. (Carnivora: Felinae)

I. bigemina var. putorii (Railliet and Lucet, 1891 (343)). (R) (Sporocysts) 8.0-12.0 x 6.0-8.0. Synonyms: Coccidium bigeminum var. putorii Railliet and Lucet, 1891 (343); Lucetina putorii (Railliet and Lucet, 1891) Henry and Leblois, 1926 (176) In Putorius foetidus ("Mustela putorius"), Polecat. (Carnivora: Mustelinae)

I. boughtoni Volk, 1938 (444). (Oocysts of I. bigemina - type.) (R) 16.8-20.4 x 10.8-12.0. (M) 15.6 x 11.2. (R) (Sporocysts) 12.0-13.2 x 8.4-9.6. (M) 12.2 x 8.9. In Didelphis virginiana, American Opossum. (Marsupialia: Didelphidae)

I. brumpti Lavier, 1941 (235). (R) 20.0-25.0 x 11.0-17.0. (M) 24.0 x 16.0. In Bufo viridis, a toad. (Amphibia: Salientia)

I. buteonis Henry, 1932 (181). (Oocysts of I. bigemina - type). (R) 16.0-19.2 x 12.8-16.0. In Buteo borealis; B. swainsoni; Accipiter cooperii: hawks. (Aves: Falconiformes). In Asio flammeus; Strix flammea; owls. (Aves: Strigiformes)

I. calotesi Bhati, 1938 (18). (R) 25.5-38.8 x 25.5-38.8. (Cf. Chakravarty and Kar, 1947 (76)). In Calotes versicolor, "Bloodsucker". (Reptilia: Sauria)

I. camillerii (Hagenmuller, 1898 (164) Sergent, 1902 (397). (M) 22.0 x 22.0. Synonym: Diplospora Camillerii Hagenmuller, 1898 (164) in Chalcides ocellatus, a lizard. (Reptilia: Sauria)

I. canis. (See I. bigemina var. canis.)

I. canivecolis Wenyon, 1923 (449) and Lee, 1934 (236). Lapsus. (See I. bigemina var. canivelocis.)

I. canivelocis (Weidman, 1915 (448)) Wenyon, 1923 (449). Synonyms: Lucetina canivelocis (Weidemann, 1915) Henry and Leblois, 1926 (176); Lucetina canivelocis Sprehn and Cramer, 1931 (413). (See I. bigemina var. canivelocis. It appears, however, that I. canivelocis is the correct name.)

I. cati Railliet and Lucet, 1891 (343). (See I. bigemina var. cati.) Synonyms: Coccidium bigeminum var. cati Railliet and Lucet, 1891 (343); Lucetina cati (Railliet and Lucet, 1891) Henry and Leblois, 1926 (176).

I. cati Marotel, 1921 (273). Synonym of I. felis Wenyon, 1923 (449). Homonym of I. bigemina var. cati Railliet and Lucet, 1891 (343).

I. cnemidóphori Carini, 1942 (58). (R) Larger forms, 26.0-30.0 x 19.0; smaller forms 19.0 x 17.0. In Cnemidóphorus lemniscatus lemniscatus, a lizard. (Reptilia: Sauria)

I. coelopeltis Galli-Valerio, 1926 (136). Lapsus for Eimeria coelopeltis (Galli-Valerio, 1926 (136)) Hoare, 1933 (184)).

I. communis-passerum Sjöbring, 1897 (409). Considered a synonym of I. lacazii Labbé, 1893 (213) by Boughton, 1938 (24).

I. corviae Ray, Shivnani, Oommon and Bhaskaran, 1952 (349,350). (R) 15.0-23.0 x 14.0-21.5. (M) 20.0 x 17.7. In Corvus macrorhynchus intermedius, Common Himalayan Crow. (Aves: Passeriformes)

?I. crotali (Triffitt, 1925 (434)) Hoare, 1933 (184). Synonym: Cryptosporidium crotali Triffitt, 1925 (434). In Crotalus confluentus, Prairie Rattlesnake; Bitis gabonica, Gaboon Viper. (Reptilia: Serpentes)

I. cruzi Pinto and Vallim, 1926 (339). (R) 20.0-22.0 x 17.0-18.0. (M) 20.7 x 17.0. In Hyla crospedospila, H. nasica, H. fuscovaria, H. rubra: South American tree frogs. (Amphibia: Salientia)

I. cryptolophae Ray, Shivnani, Oommen and Bhaskaran, 1952 (349). Synonym: I. seicercusae Ray et al. 1952 (350). (R) 22.5-30.0 x 20.0-25.0. (M) 24.8 x 33.3. In Seicercus xanthaschistos, Gray-headed Flycatcher-Warbler. (Aves: Passeriformes)

I. dirumpens Hoare, 1933 (184). (Oocysts of I. bigemina-type) (M) (Non-sporulated) 15.2 x 11.2; (Sporulated) 16.0-16.8 x 9.6. (R) (Sporocyst measurements 11.2 x 9.6-10.4 x 8.0. In Bitis arietans, Puff Adder. (Reptilia: Serpentes)

I. dirumpens var. americana Roudabush, 1937 (379). (Oocysts of I. bigemina-type) (R) 17.6-22.0 x 10.1-14.5. (M) 19.6 x 11.8. (R) (Sporocyst measurements) 9.6-13.2 x 8.8-11.0. (M) 9.9 x 11.2. In Pituophis sayi sayi, Bull Snake. (Reptilia: Serpentes)

I. dutoiti Yakimoff, Matikaschwili and Rastegaïeff, 1933 (507). (M) Round forms, 11.0 x 11.0; oval forms, 11.5 x 9.6. Synonym: Eimeria dutoiti Yakimoff, Matikaschwili and Rastegaïeff, 1933 (507)). Lapsus. In Canis aureus, Asiatic Jackal. (Carnivora: Caninae)

I. erinacei Yakimoff and Gousseff, 1936 (495). (M) ca. 32.1 x 25.2. In Erinaceus europaeus, Hedgehog. (Insectivora: Erinaceidae)

I. felis Wenyon, 1923 (449). (R) 39.0-48.0 x 26.0-37.0. Synonyms: I. cati Marotel, 1921 (272); Lucetina felis (Wenyon, 1923) Henry and Leblois, 1925 (176); Lucetina felis Kotlán and Pospesch, 1933 (209). In Canis familiaris, Dog; Felis domestica, Cat; Felis leo, Lion; possibly certain other carnivores. (Carnivora: Caninae and Felinae, resp.)

I. felis var. servalis Mackinnon and Dibb, 1938 (266). (R) 26.3-33.0 x 22.5-27.0. In Felis serval, Serval. (Carnivora: Felinae)

I. fonsecai Yakimoff and Matschoulsky, 1940 (523). (R) 22.0-32.0 x 20.0-30.0. (M) 25.4 x 23.2. In Ursus arctos isabellinus, Red Bear. (Carnivora: Ursidae)

I. fragilis Léger, 1904 (240, 234). (R) 19.0-22.0 x 14.0-15.0. In Vipera aspis, European Asp. (Reptilia: Serpentes)

I. freundi Yakimoff and Grousseff, 1935 (486). (R) Type 1, round, 13.4 -24.4; type 2, subspherical, 19.5-26.8 x 17.1-24.4; type 3, egg-shaped, 24.4 x 19.5-20.7. In Cricetus cricetus, Common Hamster. (Rodentia: Cricetinae)

I. fringillae Yakimoff and Gousseff, 1938 (498). (M) Round forms, 20.0 x 20.0; oval forms, 24.1 x 19.4. In Fringilla coelebs, Chaffinch. (Aves: Passeriformes)

I. garrulae Ray, Shivnani, Oommen and Bhaskaran, 1952 (349, 350). 20.0-22.5 x 17.5-21.3. (M) 20.6 x 19.8. In Garrulax lineatus lineatus, Streaked Laughing Thrush. (Aves: Passeriformes)

I. garrulusae Ray, Shivnani, Oommen and Bhaskaran, 1952 (349, 350). (R) 25.0-27.5 x 20.0-25.0. (M) 25.2 x 21.2. In Garrulus glandarius bispecularis, Himalayan Jay. (Aves: Passeriformes)

I. ginginiana Chakravarty and Kar, 1944 (72). (R) 22.0-24.2. In Acridotheres ginginianus, Bank Mynah. (Aves: Passeriformes)

I. ginginiana var. tristis Chakravarty and Kar, 1947 (75). (R) 24.2-28.0 x 19.8-24.2. In Acridotheres tristis tristis, Common Mynah. (Aves: Passeriformes)

I. gürsae Yakimoff and Matschoulsky, 1937 (515). (R) Round forms, 24.0-34.0; oval forms, 30.0-34.0 x 26.0-32.0. (M) Round forms, 30.6 x 30.6; oval forms, 32.0 x 29.5. In Vipera lebetina, Levantine Viper. (Reptilia: Serpentes)

I. hemidactyli Carini, 1936 (42). (R) 20.0-25.0. In Hemidactylus mabujae, a gecko. (Amphibia: Sauria)

I. henryi Yakimoff and Matikaschwili, 1932 (503). Synonyms of Caryospora henryi (Yakimoff and Matikaschwili, 1932 (503) Yakimoff and Matschoulsky, 1936 (512).

I. hominis (Railliet and Lucet, 1891 (343)) Wenyon, 1923 (449). (M) (Sporocysts) 14.8 x 9.8. Synonyms: Coccidium bigeminum var. hominis Railliet and Lucet, 1891 (343) Lucetina hominis Henry and Leblois, 1926 (176). Possible synonym of I. bigemina (Stiles, 1891 421)). In Homo sapiens, Man. (Primates: Anthropoidea)

I. hylae Mesnil, 1907 (283). (Sporulates in intestine; oocysts thin-walled.) (R) 30.0-35.0 x 20.0-25.0. (M) (Sporocysts) 23.0 x 17.0. In small intestine of Hyla arborea, a tree frog. (Amphibia: Salientia)

I. incerta Schneider, 1881 (393). Synonym of Isospora rara Schneider, 1881 (392).

I. jacarei Carini and Biocca, 1940 (59). (R) 14.0-16.0 x 13.0. In Caiman latirostris, Jacaré (a crocodile). (Reptilia: Crocodilia)

I. jeffersonianum Doran, 1953 (109). (R) 18.5-22.0. In Ambystoma jeffersonianum, Blue-Spotted Salamander. (Amphibia: Caudata)

I. knowlesi Ray and Das Gupta, 1937 (360). (M) 20.0 x 20.0. In Hemidactylus flavividris, an Indian Gecko. (Reptilia: Sauria)

I. lacazii Labbé, 1893 (213). (R) 23.0-25.0 x 23.0-25.0. In Carduelis carduelis carduelis, European Goldfinch; Alauda arvensis arvensis, European Skylark; possibly many other passerine birds, though inter-specific cross-infections are lacking. (Aves: Passeriformes)

I. laguri Iwanoff-Gobzem, 1934 (193). (R) 24.2-32.2 x 15.6-21.8. (M) 28.0 x 19.0. In Lagurus lagurus, Gray Lemming. (Rodentia: Microtinae)

I. laidlawi Hoare, 1927 (183). (R) 32.0-36.8 x 27.2-30.4. (M) 29.0 x 34.0. In Putorius putorius var. furo, Ferret; Mustela vision, Mink. (Carnivora: Mustelinae)

I. laverani (Hagenmuller, 1898 (165)) Sergent, 1902 (397). (M) Sporocyst measurements: 12.0 x 10.0. Synonym: Diplospora laverani Hagenmuller, 1898 (165); Lucetina laverani (Hagenmuller, 1898) Henry and Leblois, 1926 (176). In Coelopeltis lacertina, a snake. (Reptilia: Serpentes)

I. lenti Pinto, 1934 (337). (M) 13.0 x 9.8-10. In Bothrops jararaca, Jararaca. (Reptilia: Serpentes)

I. lieberkühni (Labbé, 1894 (217)) Laveran and Mesnil, 1902 (227). (Sporulates in kidney tubules; oocysts thin-walled). Length: 40.0. Synonyms: Klossia lieberkühni Labbé, 1894 (217); Hyaloklossia Lieberkühni (Labbé, 1894) Labbé, 1896 (220). In kidney of Rana esculenta, a frog (adult and tadpole). (Walton names also Bufo sp.? and R. temporaria.) (Amphibia: Salientia)

I. lophophinae Ray, Shivnani, Oommen and Bhaskaran, 1952 (349, 350). (R) 22.5-27.5 x 20.0-22.5. (M) 24.2 x 20.8. In Parus dichrous, Brown Crested Tit. (Aves: Passeriformes)

I. lutreolinae Carini, 1939 (50). (R) 20.0-22.0 x 17.0-19.0. In Lutreolina crassicauda, "Guaicuica" (an opossum). (Marsupialia: Didelphidae)

I. lyruri Galli-Valerio, 1931 (140). (M) 15.0 x 15.0. Believed to be an Eimeria by a number of authors, including the present. In Lyrurus tetrix, a grouse. (Aves: Galliformes)

I. melis Pellérdy, 1955 (Acta Vet. Acad. Sci. Hung. 5:421-434. In Meles taxus, (Old World) Badger. (Carnivora: Melinae)

I. mesnili Sergent, 1902 (397). (M) 30.0 x 30.0. In Chamaeleo vulgaris, Chameleon. (Reptilia: Sauria)

I. minuta Mitra and Das Gupta, 1937 (288). ("Maximum size") 15.0 x 7.5. In Naja naja, Asiatic or Indian Cobra. (Reptilia: Serpentes)

I. monedulae Yakimoff and Matschoulsky, 1936 (511). (R) Round forms, 16.0-20.0; oval forms, 16.0-22.0 x 14.0-18.0. (M) Round forms, 18.0 x 18.0; oval forms, 20.0 x 18.0. In Corvus ("Colocus") monedula collaris, Collared Jackdaw. (Aves: Passeriformes)

I. muniae Chakravarty and Kar, 1944 (72). (R) 14.4 x 10.3. In Munia malacca malacca, Black-Headed Munia. (Aves: Passeriformes)

I. mustelae Galli-Valerio, 1932 (141). (M) 7.0 x 2.25. (Sic; Typographical error?) In Mustela martes, Pine Marten. (Carnivora: Mustelinae)

I. naiae Fantham, 1932 (122). (R) 13.6 x 8.2 to 20.0 x 14.3. (M) 17.0 x 11.0. In Naja nivea (= "Naja flava"), Cape Cobra; Crotalus horridus, Common Rattlesnake. (Reptilia: Serpentes)

I. natalis Elsdon-Dew, 1953 (117). (R) 30 x 24 - 25 x 21. Synonym: I. rivolta (Elsdon-Dew 1953 (118). In Homo sapiens. Man. (Mammalia: Anthropoidea)

I. natricis Yakimoff and Gousseff, 1935 (485). (R) 12.2-15.9 x 12.2-15.9. (M) In Natrix ("Tropidonotus") natrix, Common Grass Snake. (Reptilia: Serpentes)

I. neivai Pinto and Maciel, 1929 (338). (R) 19.0-21.0 x 11.0-13.0. In Bothrops jararaca ("Lachesis lanceolatus"), Jararaca. (Reptilia: Serpentes)

I. neos Yakimoff and Gousseff, 1936 (495). (R) 23.2-29.3 x 19.5-24.4. (M) 26.0 x 22.4. In Rana arvalis, "Spitzschwänzige Frösche". (Amphibia: Salientia)

I. nucifragae Galli-Valerio, 1933 (142). (M) 24.0 x 21.0. In Nucifraga caryocatactes, Nutcracker. (Aves: Passeriformes)

I. parusae Ray, Shivnani, Oommen and Bhaskaran, 1952 (350). Synonym of I. lophophniae Ray et al., 1952 (349).

I. passerum. (See I. communis-passerum.)

I. perronciti Carpano, 1937 (64). (R) 15.0-25.0 (ordinarily). In Pyrrhula europaea, Bullfinch. (Aves: Passeriformes)

I. phisalix Yakimoff and Gousseff, 1934 (482). (R) 30.0-32.0 x 14.0. (M) 31.2 x 14.0. In Elaphe quatuorlineata sauromates, Four-Lined Snake. (Reptilia: Serpentes)

I. psittaculae Chakravarty and Kar, 1947 (75). (R) 22.0-26.4 x 13.2. In Psittacula eupatria nipalensis, Large Indian Paroquet; Elathea jocosa emeria, Red Whiskered Bulbul. (Aves: Psittaciformes)

I. putorii Railliet and Lucet, 1891 (341). (See I. bigemina var. putorii.) Synonym: Coccidium bigeminum var. putorii Railliet and Lucet, 1891 (341); Lucetina putorii (Railliet and Lucet, 1891) Henry and Leblois, 1926 (176).

I. ranae (Rivolta, 1878) Dobell, 1909 (101). Synonym: Cytospermium ranae Rivolta, 1878 (375). In Rana esculenta, a frog. (Amphibia: Salientia).

I. rangiferis Yakimoff, Matschoulsky and Spartansky, 1937 (525). (M) 30.0 x 24.0. In Rangifer tarandus, Reindeer. (Artiodactyla: Odocoileini)

I. rara Schneider, 1881 (391). (Type species.) Synonym: Isospora incerta Schneider, 1881 (392). In Limax cinereo-niger or L. griseus, "Black Slug." (Mollusca: Gastropoda)

I. rastegaïev Yakimoff and Matikaschwili, 1933 (504). (R) 16.5-21.0 x 15.4-20.0. (M) 19.1 x 17.4. In Erinaceus europaeus, Hedgehog. (Insectovora: Erinaceidae)

I. rivolta (Grassi, 1879 (156)). (R) 20.0-25.0 x 15.0-20.0. Synonyms: Coccidium rivolta Grassi, 1879 (156); Lucetina rivoltai (Grassi, 1881) Henry and Leblois, 1926 (176); Lucetina rivolta Kotlán and Pospesch, 1933 (209). In Canis familiaris, Domestic Dog; Canis dingo, Dingo; Felis domestica, Cat; Homo sapiens, Man. (Cf. Elsdon-Dew and Freedman, 1953 (118)). (Carnivora: Caninae, Felinae, and Homininae, resp.)

I. rivoltae Labbé, 1893 (213). (R) 16.0-18.0. (14.8-17.8 for Wagtail parasites.) Considered synonym of I. lacazei (=I. lacazii) by Labbé, 1896 (220), and Boughton, Boughton, and Volk, 1938 (24), and a homonym by Becker, 1934 (10). Use of name continued, however, by Misra, 1947 (286) for parasite of Motacilla alba, Wagtail. In Fringilla coelebs coelebs, Chaffinch; Lanius collurio collurio, a shrike; Parus caeruleus caeruleus, Titmouse. (Aves: Passeriformes)

I. rocha-limae Yakimoff and Gousseff, 1936 (493). (R) 22.8-24.5 x 18.4-22.8. (M) 23.9 x 19.9. In Pica pica European Magpie. (Aves: Passeriformes)

I. rodhaini Yakimoff and Matschoulsky, 1938 (517). (M) Round forms,

22.9 x 22.9; oval forms, 24.9 x 22.6. In Corvus sp., a raven. (Aves: Passeriformes)

I. seicercussae Ray, Shivnani, Oommen and Bhaskaran, 1952 (350). Synonym of I. cryptolophae Ray et al., 1952 (349).

I. schmaltzi Yakimoff and Gousseff, 1936 (494). (R) 24.4-28.1 x 24.4-28.1. In Erinaceus europaeus, Hedgehog. (Insectivora: Erinaceidae)

I. stomaticae Chakravarty and Kar, 1944 (73,77). (R) 24.2 x 15.4-20.0. In Bufo stomaticus, an Indian toad. (Amphibia: Salientia)

I. strigis Yakimoff and Matschoulsky, 1937 (514). (M) Round forms, 22.2 x 22.2; subspherical forms, 23.1 x 20.9. In Asio flammeus leucopsis, an owl. (Aves: Strigiformes)

I. struthionis Yakimoff, 1940 (478). (M) 30.6 x 30.6. In Struthio camelus, Ostrich. (Aves: Struthioformes)

I. sturniae Chakravarty and Kar, 1947 (75). (R) 17.6-19.8 x 11.0-13.2. In Sturnia malabarica malabarica, Grey-Headed Mynah. (Aves: Passeriformes)

I. suis Biester 1943 (In Becker, 1934 (10, p.106); see also Biester and Murray, 1934 (19,20). (R) 20.0-24.0 x 18.0-21.0. (M) 22.5 x 19.4. In Sus scrofa domestica, Domestic Swine. (Artiodactyla: Suiformes)

I. temenuchii Chakravarty and Kar, 1944 (72). (R) 22.0-24.2 x 19.8-22.0. In Temenchus pagodarum. (Aves: Passeriformes)

I. teres Iwanoff-Gobzem, 1934 (193). (R) 24.2-36.0 x 24.2-36.0. In Lagurus lagurus, Gray Lemming. (Rodentia: Cricetinae)

I. theileri Yakimoff and Lewkowitsch, 1932 (502). (R) 21.2 x 17.1-18.0. In Canis aureus, Asiatic Jackal. (Carnivora: Caninae)

I. upupae Chakravarty and Kar, 1947 (75). (R) 15.4-19.8 x 13.3. In Upupa epops orientalis, Indian Hoopoe; Dicrurus macrocercus macrocercus, Black Drongo. (Aves: Caraciiformes and Passeriformes, resp.)

I. varani Yakimoff, 1938 (476). (R) (Sporocysts) 10.8-14.4 x 9.0-10.8. (M) (Sporocysts) 12.8 x 9.5. In Varanus griseus, Monitor. (Reptilia: Sauria)

I. viverrae Adler, 1924 (1). (R) 19.0-27.5 x 15.2-24.7. (Commonest size) 22.8 x 19.0. In Viverra civetta, Civet Cat. (Carnivora: Viverrinae)

I. volki Boughton, 1937 (22). (R) 14.0-21.0 x 14.0-20.0. (M) 18.0 x 16.0. In Parotia lawesi lawesi, Six-Plumed Bird of Paradise. (Aves: Passeriformes)

I. vulpina Nieschulz and Bos, 1933 (303). (R) 21.0-32.0 x 19.0-27.0. (M) 24.9 x 21.4. In Vulpes fulva, "Silver Fox", color variety of North American Red Fox. (Carnivora: Caninae)

I. vulpis Galli-Valerio, 1931 (140). (M) 25.0 x 24.0. Homonym: ? Isospora vulpis (Wetzel, 1938). In Vulpes vulgaris, Red Fox. (Carnivora: Caninae)

?I. vulpis (Wetzel, 1938) (452). (R) (Sporocyst) 12.0-15.2 x 8.0-10. (M) (Sporocyst) ca. 13.5 x 8.0. Synonym: Cryptosporidium vulpis Wetzel, 1938 (452). Homonym of Isospora vulpis Galli-Valerio, 1931 (140). In Vulpes vulpes, Old World Red Fox. (Carnivora: Caninae)

I. wenyoni Ray and Das Gupta, 1935 (356). (R) 16.0-20.0 x 11.0-14.0. In Bufo melanosticus, Indian Toad. (Amphibia: Salientia)

I. wladimirovi Yakimoff, 1930 (459,460). (R) 18.0-25.0 x 15.5-21.2. (M) 21.4 x 17.7. In Hyla arborea, Tree Frog. (Amphibia: Salientia)

I. xantusiae Amrein, 1952 (8). (R) 25.0-27.0. In Xantusia vigilis, Yucca Night Lizard; Xantusia henshawi, Granite Night Lizard. (Reptilia: Sauria)

I. zosteropis Chakravarty and Kar, 1947 (75). (R) 17.6-22.2 x 13.2-19.8. Synonym: I. zosterpsae Chakravarty and Kar, 1947 (75). Lapsus. In Zosterops palpebrosa palpebrosa, Indian White Eye; Thereiceryx zeylanicus caniceps (provisionally). (Aves: Passeriformes)

7. DORISIELLA Ray, 1930 (351)

Type species: D. scolelepidis Ray, 1930 (351)

D. arizonensis Levine, Ivens, and Kruidenier, 1955 (259). (R) 20.8-22.9 x 20.8-21.8. (M) 21.8 x 21.0. In Neotoma lepida, Desert Woodrat. (Rodentia: Cricetinae)

D. aethiopsaris Chakravarty and Kar, 1947 (303). (R) Subspherical forms, 28.6-30.8 x 24.2-26.4; oval forms, 33.0-38.8 x 24.2-26.4. In Aethiopsar fuscus fuscus, Jungle Mynah. (Aves: Passeriformes)

D. hareni Chakravarty and Kar, 1944 (303). (R) 18.5-22.6 x 18.5-22.6. (M) 20.6 x 20.6. In Munia malacca malacca, Black-Headed Munia; Amandava anadava, Indian Red Munia; Munia articapilla rubronigra, Northern Chestnut-Bellied Munia; Uroloncha malabarica, White-Throated Munia; Uroloncha punctulata punctulata, Indian Spotted Munia. (Aves: Passeriformes)

D. hoarei Yakimoff and Gousseff, 1935 (483). (M) Round forms, 20.2 x 20.2; oval forms, 22.1 x 18.7. In Elaphe quatuorlineata, Four-Lined Snake. (Reptilia: Serpentes)

D. scolelepidis Ray, 1930 (350). (Type species) (R) (spore) 12.0-18.0 x 6.0-10.0; (Macrogametocyte)28.9-30.0 x 8.0-10.0; (No definite oocyst wall.) In Scolelepis fuliginosa, a polychaete worm. (Annelida: Polychaeta)

8. EIMERIA Schneider, 1875 (391)

Type species: E. falciformis (Eimer, 1870 (115)) Schneider, 1875 (391). Synonyms: Gregarina Eimer, 1870 (115) pro parte; Cytospermium Rivolta, 1878 (375) pro parte; Psorospermium Rivolta, 1878 (375) pro parte; Coccodium Leuckart, 1879 (250) pro parte; Orthospora Schneider, 1881 (392) pro parte: Karyophagus Steinhaus, 1889 (418); Cytophagus Steinhaus, 1891 (419)-Clobidium Flesch, 1883 (128) pro parte; Acystis Labbé, 1894 (216); Pfeifferia Labbé, 1894 (217); Bananella Labbé, 1895 (219); Goussia Labbé, 1896 (220); Crystallospora Labbé, 1896 (220); Pfeifferella Labbé, 1899 (221); Paracoccidium Laveran and Mesnil, 1902 (228); Marotelia Ratz, 1905 (Fide Marotel, 1949 (273)); Jarrina Léger and Hesse, 1922 (245).

E. acanthodactyli (Phisalix, 1930 (331)) Levine and Becker, 1933 (258). (M) 31.5 x 21.0. Synonym: Coccidium acanthodactyli Phisalix, 1930 (331). In Acanthodactylus scutellatus, Fringe-Toed Lizard. (Reptilia: Sauria)

E. acervulina Tyzzer, 1929 (441). (R) 17.7-20.2 x 13.7-16.3. (M) 19.5 x 14.3. In Gallus domesticus, Common Fowl or Chicken; Colinus virginianus virginianus, Bobwhite?; Lophortyx californica vallicola, California Valley Quail?; Oreortyx picta plumifera, Plumed Quail?. (Aves: Galliformes)

E. adenoeides Moore and Brown, 1951 (289, 290). (R) 19.0-31.3 x 12.6-20.9. (M) 25.6 x 16.6. In Meleagris gallopavo gallopavo, Domesticated Turkey. (Aves: Galliformes)

E. adleri Yakimoff and Gouseff, 1936 (492). (R) Round forms, 18.4-23.5; subspherical forms, 27.5-39.6 x 25.9-27.9. In Gelben Fuchs ". (Carnivora: Caninae)

E. aemula Yakimoff, 1931 (462). Considered synonym of E. arloingi by Hardcastle, 1943 (171).

E. aenula. Lapsus for E. aemula.

E. aesculapi Carini, 1933 (38). (M) 15.0 x 13.0. In Erythrolamprus aesculapi, a non-venomous Brazilian snake. (Reptilia: Serpentes)

E. agamae (Laveran and Petit, 1910 (229)) Reichenow, 1921 (370). (R) 20.0-25.0 x 11.0-14.0. Synonym: Coccidium agamae Laveran and Petit, 1910 (229). In Agama colonorum, a lizard. (Reptilia: Sauria)

E. aguti Carini, 1935 (39). (R) 16.0-17.0 x 16.0-17.0. In Aguti aguti (="Cotia vermelha"), Lowland Paca. (Rodentia: Dasyproctinae)

E. ah-sa-ta Honess, 1942 (191). (R) 29.5-33.5 x 21.6-24.9. (M) 31.7 x 23.2. In Ovis canadensis canadensis, Rocky Mountain Bighorn Sheep; Ovis aries, Domestic Sheep. (Artiodactyla: Caprinae)

E. alabamensis Christensen, 1941 (85). (R) 13.0-24.0 x 11.0-16.0. (M) 18.9 x 13.4. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. alactagae Iwanoff-Gobzem, 1934 (193). (R) 22.3-26.4. (M) 24.4 x 24.4. In Allactaga major (="A. jaculus"), "Jumping Hare" or Five-Toed Jerboa. (Rodentia: Dipodinae)

E. alburni (Stankovitch, 1920 (414)) Yakimoff, 1929 (457). (R) 19.0-20.0 x 19.0-20.0. Synonym: Goussia alburni Stankovitch, 1920 (414). In Cyprinus gobio, Whitefish; Leuciscus rutilus, Common Roach; Scardinius erythrothalmus, Red Roach. (Pisces: Ostariophysi)

E. amarali Pinto, 1928 (335). (M) 19.6 x 16.8. In Bothrops neuweidii, Maximilian's Viper or Jararaca do Rabo Branco. (Reptilia: Serpentes)

E. ambystomae Saxe, 1955? (387). (R) 24.5-35.9 x 14.7-19.6. (M) 31.2 x 17.7. In Ambystoma tigrinum; Desmognathus quadramaculata; D. monticola; salamanders. (Amphibia: Caudata)

E. americana Carvalho, 1943 (66). (R) 34.3-42.8 x 18.3-25.0. (M) 38.1 x 21.0. In Lepus (Poecilolagus) townsendii campanius, White-Tailed Jackrabbit. (Lagomorpha: Leporinae)

E. amydae Roudabush, 1937 (379). (R) 16.7-23.7 x 12.3-16.7. (M) 19.6 x 14.6. In Amyda spinifera, Soft-Shelled Turtle. (Reptilia: Chelonia)

E. anatis Scholtyseck, 1954 (Arch. f. Protistenk. 100:431-434). (R) 14.4-19.2 x 10.8-15.6. In Anas domesticus, Domestic Duck. (Aves: Anseriformes)

E. andrewsi Yakimoff and Gouseff, 1935 (487). (R) 19.8-22.5 x 14.4-16.2. (M) 20.9 x 15.2. In "Eichhörnchen" (Sciurus). (Rodentia: Sciurinae)

E. anguillae Léger and Hollande, 1922 (247). (M) 10.0 x 10.0. In Anguilla vulgaris, Eel. (Pisces: Apodes)

E. angusta Allen, 1934 (4). (R) 16.5-17.5 x 27.0-33.0. In Bonasa umbellus, Ruffed Grouse; Canachites canadensis, Spruce Grouse; Centrocercus urophasianus, Sage Hen; Pedioecetes phasianellius campestris, Sharp-Tailed Grouse; Tetrastes bonasia. (Aves: Galliformes)

E. anseris Kotlán 1932 (206), emend. Kotlán, 1933 (207). (R) 16.0-23.0 x 13.0-18.0. In Anser anser anser, Domestic Goose. (Aves: Anseriformes)

E. antelocaprae Huizinga, 1942 (190). (R) 24.6-35.2 x 21.1-29.5. (M) 30.8 x 26.0. In Antilocapra americana, Pronghorn (= "American Antelope"). (Artiodactyla: Antilocaprinae)

E. apionodes Pellérdy, 1954 (Acta Vet. Acad. Sci. Hung. 4:187-191). (R) 17-23 x 13-18. In Apodemus ("Mus") flavicollis, Woods Mouse (Old World). (Rodentia: Murinae)

E. apodemi Pellérdy, 1954 (Acta Vet. Acad. Sci. Hung. 4:187-191). (R) 21-27 x 15-22. In Apodemus flavicollis, Woods Mouse (Old World). (Rodentia: Murinae)

E. arctica Yakimoff, Matschoulsky and Spartansky, 1939 (526). (M) 35.3 x 28.0. In Rangifer tarandus, Reindeer. (Artiodactyla: Odocoileini)

E. arctomysi Galli-Valerio, 1931 (140). (M) 24.0 x 20.0. In Marmota ("Arctomys") marmota, Alpine Marmot. (Rodentia: Sciurinae)

E. arkhari Yakimoff and Matschoulsky, 1937 (513). (R) 20.0-24.0 x 18.0-20.0. (M) 22.4 x 17.4. In Ovis arkhar (= "Ovis vignei"); Ovis polii polii; Ovis polii sewerzowi; Wild Sheep. (Artiodactyla: Caprinae)

E. arloingi (Marotel, 1905 (271)) Martin, 1909 (275). (M) 27.0 x 18.0. Synonyms: Coccidium arloingi Marotel, 1905 (271); Eimeria aemula Yakimoff, 1931 (462). In Capra hircus; Capra hircus angoriensis; Capra ibex, Hemmitragus jemlaicus; Ovis aries; Ovis aries germanica; Ovis aries platygura var. astracanensis; Ovis aries steatopyga; Ovis aries steatopyga var. somalica; Ovis aries strepsiceros var. hortob; Ovis musimon; Ovis polii polii; Ovis polii sewerzowi. (Artiodactyla: Caprinae)

E. arnaldoi Pinto and Maciel, 1929 (338). (R) 30.0 x 14.0-15.0. In Tamnodynastes strigilis, a non-venomous Brazilian snake. (Reptilia: Serpentes)

E. arvalis. Lapsus for E. arvicolae.

E. arvicolae (Galli-Valerio, 1905 (132)) Reichenow, 1921 (370). (R) 14.0-18.0 x 14.0-18.0. Synonyms: Eimeria arvalis (Galli-Valerio, 1905 (132)), lapsus; Coccidium arvicolae Galli-Valerio, 1905 (132). In Arvicola nivalis, Continental Field Vole. (Rodentia: Microtinae)

E. asturi Galli-Valerio, 1935 (143). (M) 10.5 x 6.0. In Astur palumbarius, Goshawk. (Aves: Falconiformes)

E. auburnensis Christensen and Porter, 1939 (86). (R) 32.0-45.5 x 20.0-25.5. (M) 38.4 x 23.1. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. avium (Rivolta, 1878 (375)) auct. Synonyms: Psorospermium avium Rivolta, 1878 (375). (According to Reichenow, 1921 (370), this species is an Isospora; others regard it as a nomen nudum for want of a recognizable description.)

E. avium intestinalis (Rivolta, 1878 (375)). Synonym: Gregarina avium intestinalis Rivolta, 1878 (375). Name is trinomial, hence invalid. (Cf. Tyzzer, 1929 (441)).

E. azerbaidjhanaica Yakimoff, 1933 (466). (M) 45.0 x 21.6. Synonym: Eimeria azerbaidshanica Yakimoff, 1933 (466). Lapsus. In Bubalus ("Buffelus") bubalis, Indian Buffalo or Water Buffalo; Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. azerbaidshanica. Lapsus for E. azerbaidjhanaica.

E. balozeti Yakimoff and Gousseff, 1938 (499). (R) 19.5-30.6 x 17.1-26.6. In Sturnus vulgaris, Starling. (Aves: Passeriformes)

E. barbeta Kar, 1944 (197). (R) 22.0-24.2 x 19.6-19.8. In Megalaima ("Cyanops") asiatica asiatica, Blue-Throated Barbet. (Aves: Piciformes)

E. beachi Yakimoff and Rastegaïeff, 1931 (529). (R) 12.8-22.1 x 12.8-22.1. (M) 16.8 x 16.8. Hardcastle (1943 (171) questions validity of this species. In Gallus domesticus, Common Fowl or Chicken. (Aves: Galliformes)

?E. beauchampi Léger and Duboscq, 1917 (243). In Glossobalanus minutus. (Chordata: Hemichordata)

E. beckeri Yakimoff and Sokoloff, 1934 (530, 531). (R) Round forms, 14.4-23.4 x 14.4-23.4; oval forms, 17.1-22.5 x 14.4-21.7. (M) Round forms, 16.9 x 16.9; oval forms, 19.2 x 16.8. In Citellus pygmaeus, Little Souslik or Steppe Squirrel. (Rodentia: Sciurinae)

E. beecheyi Henry, 1932 (179). (R) 16.0-22.4 x 12.8-10.2 (sic). (M) 19.2 x 16.0. In Citellus beecheyi, California Ground Squirrel or Gray Digger. (Rodentia: Sciurinae)

E. bélli. Lapsus for Isospora belli.

E. belawini Yakimoff, 1930 (459, 460). (M) 12.2 x 12.2. In Hyla arborea, Tree Frog (Amphibia: Salientia)

E. bigemina (Labbé, 1896 (219)) Yakimoff, 1929 (457, 458). (R) 27.0-28.0 x 27.0-28.0. Synonym: Goussia bigemina Labbé, 1896 (219). In Ammodytes tobianus. (Pisces: Percomorphi)

E. bilamellata Henry, 1932 (179). (R) 25.6-35.6 x 22.4-25.6. (M) 32.0 x 25.6. In Citellus (Callospermophilus) chrysodeirus, Golden-Mantled Ground Squirrel. (Rodentia: Sciurinae)

E. bitis Fantham. 1932 (485). (R) 27.9-36.4 x 17.8-24.3. In Bitis arientans, Puff Adder. (Reptilia: Serpentes)

E. böhmi Supperer, 1952 (423). (R) 33.8-49.0 x 24.1-33.2. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. bonasae Allen, 1934 (4). (M) 21.0 x 21.0. In Bonasa umbellus, Ruffed Grouse; Lagopus lagopus, Willow Ptarmigan; Canachites canadensis, Spruce Grouse; Pedioecetes phasianellus campestris, Sharp-Tailed Grouse; Tetrastes bonasia, Hazel Grouse. (Aves: Galliformes)

E. boormae. Lapsus for E. koormae.

E. botelhoi Carini, 1932 (34). (M) 36.0 x 28.0. In Sciurus (Guerlinguetus) ingrami, a squirrel. (Rodentia: Sciurinae)

E. boveroi Carini and Pinto, 1926 (62,63). (M) 18.3 x 18.3. In Hemidactylus mabuia, a South American gecko; Ameiva ameiva, a gecko. (Reptilia: Sauria)

E. bovis (Züblin, 1908 (537))Fiebiger, 1912 (125). (R) 12.0-25.0 x 10.0-20.0. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. brantae Levine, 1953 (257). (Typical) 23.4 x 17.7. In Branta canadensis parvipes, Lesser Canada Goose. (Aves: Anseriformes)

E. bracheti Gérard, 1913 (147). Considered synonym of E. tenella by Reichenow (1921 (370)) and Tyzzer (1929 (441)).

E. brasiliensis Torres and Ramos, 1939 (432). (M) 27.1 x 37.5. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. brevoortiana Hardcastle, 1944 (172). (R) Round forms, 17.5-30.0; oval forms, 21.2-30.0. (M) Round forms, 25.1; oval forms, 26.2 x 22.7. In Brevoortia tyrannus, Menhaden. (Pisces: Isospondyli)

E. brinkmanni Levine, 1953 (257). (R) 18.0-19.6 x 26.0-29.7. (M) 18.8 x 28.6. In Lagopus mutus rupestris, Rock Ptarmigan. (Aves: Galliformes)

E. brodeni Cerruti, 1930 (69). (R) 28.0-32.0 x 18.0-20.0. In Testudograeca, European Tortoise. (Reptilia: Chelonia)

E. brumpti Cauchemez, 1921 (67). Synonyms of E. debliecki.

E. brumpti Yakimoff and Gousseff, 1936 (489). Homonym of E. brumpti, Cauchemez, 1921 (67). Synonym of E. yakisevi, in turn a synonym of E. nonbrumpti, pro parte.

E. brunetti Levine, 1942 (261, 262). (R) 20.7-30.3 x 18.1-24.2. (M) 26.8 x 21.7. In Gallus domesticus, Common Fowl or Chicken. (Aves: Galliformes)

E. bucephalae Christiansen and Madsen, 1948 (88). (R) 25.0-39.0 x 13.0-20.0. (M) 30.3 x 15.6. In Bucephala clangula, Goldeneye. (Aves: Anseriformes)

E. bukidnonensis Tubangui, 1931 (436). (R) 46.8-50.4 x 33.3-37.8. (M) 48.6 x 35.4. In Bos Taurus, Domestic Cow; Bos ("Bibos") indicus, Zebu. (Artiodactyla: Bovinae)

E. butkai Causey, 1926 (69). Considered invalid by Kessel (1933) and Becker (1934).

E. cabassusi Carini, 1933 (37). (R) 21.0-23.0. In Cabassus unicinctus, "Tatu", an armadillo. (Edentata: Cingulata)

E. callospermophili Henry, 1932 (180). (R) 16.0-22.4 x 16.0-22.4 (sic) (M) 19.2 x 16.0. In Citellus ("Callospermophilus") chrysodeirus, Golden-Mantled Ground Squirrel. (Rodentia: Sciurinae)

E. (Globidium) cameli Henry and Masson, 1932(177). (R) 81.0-100.0 x 63.0-94.0. Homonyms: E. cameli Nöller, 1933 (307); E. cameli Iwanoff-Gobzem, 1934 (192). In Camelus dromedarius, Dromedary or One-Humped Camel. (Artiodactyla: Tylopoda)

E. cameli Nöller, 1933 (307). Homonym of E. (Globidium) cameli Henry and Masson, 1932 (177). Homonym: E. cameli Iwanoff-Gobzem, 1934 (192). In Camelus bactrianus bactrianus, Domestic Bactrian Camel. (Artiodactyla: Tylopoda)

E. cameli Iwanoff-Gobzem, 1934 (192) emend. Yakimoff and Matschoulsky, 1939 (520). Synonym: E. cameli Iwanoff-Gobzem, 1934 (192). Homonym of E. (Globidium) cameli Henry and Masson, 1932 (177), and E. cameli Nöller, 1933 (307).

E. canadensis Bruce, 1921 (28). (M) 32.5 x 23.4. Synonym: E. zurnabadensis Yakimoff, 1931 (461). In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. canaliculata Lavier, 1936 (232). (R) 36.0-42.0 x 20.0-27.0. (M) 39.0-40.0 x 23.0-25.0. In Triturus alpestris; T. cristatus; T. helveticus; T. vulgaris: newts. (Amphibia: Caudata)

E. canis Wenyon, 1923 (449). (R) 18.0-45.0 x 11.0-28.0. In Canis familiaris, Domestic Dog; Canis dingo, Dingo; Felis domestica, Cat. (Carnivora: Caninae and Felinae, Resp.)

E. canivelocis Gousseff, 1933 (150). Lapsus for Isospora canivelocis.

E. canna Triffitt, 1924 (433). (R) 23.5-34.0 x 16.5-20.0. In Taurotragus ("Oreas") canna, Eland. (Artiodactyla: Bovinae)

E. capibarae Carini, 1937 (44, 45). (R) 25.0-33.0 x 20.0-28.0. (M) 30.0 x 26.0. In Hydrochoerus hydrochaerus hydrochaerus (=Hydrochoerus capibara"), Capybara. (Rodentia: Hydrochoerinae)

E. capreoli Galli-Valerio, 1927 (137). (M) 24.0 x 13.0. In Capreolus ("Cervus") capreolus, Roe Deer; Rupicapra rupicapra, Chamois. (Artiodactyla: Odocoileinae and Caprinae, resp.)

E. carassii Yakimoff and Gousseff, 1935 (484). (R) 19.5-24.4 x 19.5-24.4. In Carassius carassius, a fish. (Pisces: Ostariophysi)

E. carinii Pinto, 1928 (334). Synonym of E. miyairii, according to Roudabush, 1937 (380).

E. carpelli Léger and Stankovitch, 1921 (248, 249). (R) 13.0-14.0 x 13.0-14.0. In Cyprinus carpio, Carp. (Pisces: Ostariophysi)

E. cati Yakimoff, 1933 (467). (M) Oval forms, 20.8 x 17.1; round forms, 18.0 x 18.0. In canis familiaris, Dog. Felis domestica, Cat. (Carnivora: Caninae and Felinae, resp.)

E. caucasica Yakimoff and Buewitsch, 1932 (479). (R) 25.2-36.0 x 14.4-21.6. (M) 32.7 x 19.0. In "Berghühnern" (Mountain Partridge), probably Alectoris graeca. (Aves: Galliformes)

E. caviae Sheather, 1924 (402). (R) 17.0-25.0 x 13.0-18.0. In Cavia porcellus (="C. cobaya"), Domesticated Guinea Pig; Cavia aperea, Wild Guinea Pig. (Rodentia: Caviinae)

E. centrocerci Simon, 1939 (404, 405). (R) 20.8-24.9 x 16.6-17.8. (M) 22.6 x 17.1. In Centrocercus urophasianus, Sage Hen. (Aves: Galliformes)

E. cerastis (Chatton, 1912 (80)) Phisalix, 1921 (319). (M) 40.0 x 20.0. Synonym: Coccidium cerastis Chatton, 1912 (80). In Cerastes cornutus; Cerastes vipera; snakes. (Reptilia: Serpentes)

E. cernua. Lapsus for E. urnula Hoare, 1933 (184).

E. cervi Galli-Valerio, 1927 (137). (M) 35.0 x 21.0. In Cervus elaphus, Red Deer; Capreolus capreolus, Roe Deer. (Artiodactyla: Cervinae and Odocoileinae, resp.)

E. chagasi Yakimoff and Gousseff, 1935 (485). (M) 14.5 x 14.5. In Sorex araneus, a shrew. (Insectivora: Soricidae)

E. chaus Rýsavý, 1954 (Česk. Parasit. 1:131-174). (R) 18.3-24.4 x 14.3-22.4. In Felis ("Chaus") chaus, Jungle Cat. (Carnivora: Felinae)

E. chrysemydis Deeds and Jahn, 1939 (99). (R) 21.0-27.0 x 13.0-18.0. (M) 23.0 x 15.0. In Chrysemys bellii marginata, Western Painted Terrapin. (Reptilia: Chelonia)

E. citelli Kartchner and Becker, 1930 (198). (R) 15.0-23.0 x 14.0-19.0. (M) 18.8 x 15.8. In Citellus tridecemlineatus, Thirteen-Lined Ground Squirrel; Citellus pygmaeus, Steppe Ground Squirrel. (Rodentia: Sciurinae)

E. clini Fantham, 1932 (122). (R) 13.6-17.7 x 11.8-15.0. In Clinus superciliosis, Klip-Fish. (Pisces: Percomorphi)

E. clupearum (Thélohan, 1894 (431)) Doflein, 1909 (106). (R) 18.0-21.0 x 18.0-21.0. Synonyms: Coccidium sp. Thélohan, 1892 (429); Coccidium clupearum Thélohan, 1894 (431); Goussia clupearum (Thélohan, 1894 (431)) Labbé, 1896 (220); Eimeria wenyoni Dobell, 1919 (103). In Alosa sardina; Clupea harengus, Herring; Clupea pilchardus, Sardine; Engraulis encrasicholus, Anchovy; Sardina melanosticta; Scomber scomber, Mackeral. (Pisces: Isospondyli)

E. cnemidophori Carini, 1941 (56). (M) 18.0 x 17.0. In Cnemidophorus lemniscatus lemniscatus, "Calango" or "Taguira", a New World lizard. (Reptilia: Sauria)

E. cobitis Stankovitch, 1924 (416). (R) 19.0-21.0. In Cobitis taenia, a fish. (Pisces: Ostariophysi)

E. coecicola Cheissin, 1946 (83). (R) 25.3-39.9 x 14.6-21.3. (M) 31.9 x 18.6. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. (Lagomorpha: Leporinae)

E. coelopeltis (Galli-Valerio, 1926 (136)) Hoare, 1933 (184). (M) 10.5 x 6.0. Synonym: Isospora coelopeltis Galli-Valerio, 1926 (136). Lapsus. In Coelopeltis lacertina, a snake. (Reptilia: Serpentes)

E. columbae Mitra and Das Gupta, 1937 (288). ("Maximum size") 16.4 x 14.4. In Columba livia intermedia, Indian Pigeon. (Aves: Columbiformes)

E. columbarum Nieschulz, 1935 (301). (R) 19.0-21.0 x 17.5-20.0. In Columba livia, Domestic Rock Pigeon. (Aves: Columbiformes)

E. (sic) commodium Shaw, 1935 (401). Nomen nudum.

E. cotiae Carini, 1935 (39). (M) 29.0 x 18.0. In Aguti aguti, "Cotia vermelha" Lowland Paca. (Rodentia: Dasyproctinae)

E. cotti Gauthier, 1921 (145). (R) 10.0-11.0 x 10.0-11.0. Synonym: Eimeria votti Gauthier, 1921 (145). Lapsus. In Cottus gobio, "Bullhead" or Sculpin. (Pisces: Scleroparei)

E. coturnicis Chakravarty and Kar, 1947 (75). (R) 26.4-38.8 x 19.8-26.4. In Coturnix coturnix coturnix, Common Grey Quail (of India). (Aves: Galliformes)

E. coypi Obitz and Wadowski, 1937 (308). (M) 22.8 x 14.7. In Myocastor coypus (="Myopotamus caipus"), Coypu or Nutria. (Rodentia: Capromidae)

E. crandallis Honess, 1942 (189). (R) 17.5-23.2 x 17.5-21.6. (M) 21.9 x 19.4. In Ovis canadensis canadensis, (Rocky Mountain) Bighorn Sheep. (Artiodactyla: Caprinae)

E. criceti Nöller, 1920 (304). Synonym: E. falciformis var. criceti Nöller, 1920 (304). (R) 18.0-22.0 x 11.0. In Cricetus cricetus, Common Hamster. (Rodentia: Cricetinae)

E. cristalloides (Thélohan, 1893 (430)) Doflein, 1909 (106). (R) 20.0-25.0. Synonyms: Coccidium cristalloides Thélohan, 1893 (430); Crystallospora thélohani Labbé, 1896 (220). In Motella fusca; Motella maculata; Motella tricirrata; all rocklings. (Pisces: Anacanthini)

E. crocidurae Galli-Valerio, 1933 (142). (M) 16.0 x 12.7. In Sorex araneus, a shrew. (Insectivora: Soricidae)

E. crotali Phisalix, 1919 (318). (M) 32.0 x 22.0. In Crotalus terrificus, Tropical Rattlesnake; Bitis gabonica, Gaboon Viper. (Reptilia: Serpentes)

E. cruciata (Thélohan, 1892 (429)) Yakimoff, 1929 (457). (M) 25.0 x 25.0. Synonyms: Cocci dium cruciatum Thélohan, 1892 (429); Goussia cruciata (Thélohan, 1892 (429)) Labbé, 1896 (220). In Caranx trachurus, Horse Mackerel; Trachurus trachurus. (Pisces: Percomorphi)

E. cuniculi (Rivolta, 1878 (375)). Synonym of E. stiedae Lindemann, 1865 (263).

E. cyanophlyctis Chakravarty and Kar, 1944 (73, 77). (R) 15.4-19.8 x 15.4-17.6. In Rana cyanophlyctis, an Indian frog. (Amphibia: Salienta)

E. cylindrica Ray and Das Gupta, 1936 (358). Homonym of Eimeria cylindrica Wilson, 1931 (455). Synonym of E. gupti Bhatia, 1938 (18).

E. cylindrica Wilson, 1931 (455). (R) 19.4-26.8 x 11.9-14.9. (M) 23.3 x 13.3. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. cylindrospora Stankovitch, 1921 (415). (R) 10.0-11.0 x 10.0-11.0. In Alburnus lucidus, Small Bleak. (Pisces: Ostariophysi)

E. cynomysis Andrews, 1928 (9). (R) 33.0-37.0 x 28.0-32.0. (M) 35.4 x 30.0. In Cynomys ludovicianus, Prairie Dog. (Rodentia: Sciurinae)

E. cyprini (Plehn, 1924 (339)) Yakimoff, 1929 (457). (M) 9.0 x 9.0. In Cyprinus carpio, Carp; Tinca vulgaris, a tench; Tinca tinca, a tench. (Pisces: Ostariophysi)

E. cyprinorum Stankovitch, 1921 (415). (R) 12.0-13.0 x 12.0-13.0. In Barbus fluviatilis, Barbel; Leuciscus rutilus, Common Roach; Phoxinus laevis; Scardinius erythrothalmus, Red Roach. (Pisces: Ostariophysi)

E. cystis-felleae Debaisieux, 1914 (98). (R) 30.0-38.0 x 20.0-25.0. In Natrix natrix, Common Grass Snake. (Reptilia: Serpentes)

E. cystis-felleae var. americana Amrein, 1952 (8). (Oocyst size not stated). In Xantusia riversiana riversiana, Night Lizard, and Uta stansburiana, Side-Blotched Lizard. (Reptilia: Sauria)

E. debliecki Douwes, 1921 (112). (M) 20.8 x 16.0. Synonyms: ? Coccidium suis Jaeger, 1921 (194); Eimeria brumpti Cauchemez, 1921 (69); Eimeria jalina Krediet, 1921 (211, 212); Eimeria suis Nöller, 1921 (306); "Eimeria tuis Nöller, 1921", lapsus. In Sus scrofa domestica, Domestic Pig; Sus scrofa scrofa, Wild Boar. (Artiodactyla: Suiformes)

E. delagei (Labbé, 1893 (215)) Reichenow, 1921 (370). (R) 20.0-22.0 x 16.0-17.0. In Emys orbicularis, European Pond Turtle. (Reptilia: Chelonia)

E. delagei var. marginata Deeds and Jahn, 1939 (100). (R) 20.0-28.0 x 15.0-21.0. In Chrysemys bellii marginata, Western Painted Terrapin. (Reptilia: Chelonia)

E. dendrocopi Levine, 1953 (257). See E. lyruri. Synonym: E. lyruri of the woodpecker (Dendrocops major).

E. dericksoni Roudabush, 1937 (379). (R) 12.3-16.7 x 10.6-15.8. (M) 14.6 x 12.9. In Amyda spinifera, Soft-Shelled Turtle. (Reptilia: Chelonia)

E. dicrostonicis Levine, 1952 (255). (R) 26.8-30.8 x 23.4-26.8. (M) 29.1 x 24.8. In Dicrostonyx groenlandicus richardsoni, Varying Lemming. (Rodentia: Microtinae)

E. didelphidis Carini, 1936 (40). (M) 16.0 x 16.0. In Didelphis aurita, South American Opossum. (Marsupialia: Didelphidae)

E. dispersa Tyzzer, 1929 (441). (R) 17.2-26.4 x 15.4-22.4. (M) 22.8 x 18.8. In Colinus virginianus virginianus, Bobwhite; Phasianus colchicus torquatus, Ring-Necked Pheasant; Phasianus colchicus colchicus, English Pheasant; Meleagris gallopavo gallopavo, Domestic Turkey. Bonasa umbellus, Ruffed Grouse; Pedioecetes phasianellus campestris, Sharp-Tailed Grouse. (Aves: Galliformes)

E. dispersa (slowly developing variety) Tyzzer, 1929 (441). (R) 19.8-27.1 x 16.5-20.5. (M) 23.9 x 18.1. In Colinus virginianus virginianus, Bobwhite. (Aves: Galliformes)

E. dissimilis Yakimoff and Gousseff, 1935 (485). (R) 18.4-32.9 x 13.4-24.4. (M) 28.0 x 19.4. In Sorex araneus, a shrew. (Insectivora: Soricidae)

E. dissorta Saxe, 1955 ? (387). (R) 27.2-31.2 x 14.4-16.0. (M) 29.2 x 15.5. In Ambystoma tigrinum, a salamander. (Amphibia: Caudata)

E. dromedarii Yakimoff amd Matschoulsky, 1939 (520). (R) 23.1-32.6 x 20.0-25.2. (M) 27.7 x 23.2. Synonyms: Eimeria cameli Nöller, 1933 (307), pro parte; Eimeria cameli Iwanoff-Gobzem, 1934 (192), pro parte. In Camelus dromedarius, Dromedary, or One-Humped Camel. (Artiodactyla: Tylopoda)

E. dubia Railliet, 1895 (341). Inadequately described; nomen nudum.

E. dukei Lavier, 1927 (231). (R) Round forms, 20.0-24.0 x 20.0-24.0; oval forms, 23.0-25.0 x 18.5-22.0. In Nyctinomus pumilus; Nyctinomus limbatus; both free-tailed bats. (Chiroptera: Vespertilionoidea)

E. dura Crouch and Becker, 1931 (95). Synonyms of E. monacis Fish, 1930 (127).

E. dutoiti. Lapsus for Isospora dutoiti.

E. eimeria (Roche, 1917 (376)). Synonym: Cocci eimeria Roche, 1917 (376). Nomen nudum.

E. ekdysios Triffitt, 1928 (435). (R) 19.0-40.0 x 12.0-25.0. (M) 29.6 x 17.7. In Tachypodoiulus niger, a millipede. (Arthropoda: Diplopoda)

E. elegans Yakimoff, Gousseff and Rastegaïeff, 1932 (501). (R) 23.4-27.8 x 18.0-23.4. (M) 34.2 x 19.8. In Gazella subgutturosa, Goitred Gazelle or Persian Gazelle. (Artiodactyla: Antilopinae)

E. ellipsoidalis Becker and Frye, 1929 (11). (R) 20.0-26.0 x 13.0-17.0. (M) 23.4 x 15.9. In Bos taurus, Domestic Cow; Bos (Bibos) frontalis, Gayal; Bos ("Bibos") indicus, Zebu; Bison bonasus, European Bison or Wisent. (Artiodactyla: Bovinae)

E. elongata Marotel and Guilhon, 1941 (274). (R) 35.0-40.0 x 17.0-20.0. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. (Lagomorpha: Leporinae)

E. environ Honess, 1939 (187). (R) 20.0-32.5 x 14.3-22.8. (M) 25.7 x 18.5. In Sylvilagus nuttallii grangeri, Granger's Cottontail;

Silvilagus floridanus mearnsi, Mearns' Cottontail. (Lagomorpha: Leporinae).

? E. epidermica Léger and Duboscq, 1917 (243). In Glossobalanus. (Chordata: Hemichordata)

? E. escomeli Rastegaïeff, 1930 (345). (M) Oval forms, 20.7 x 17.1; round forms, 18.0 x 18.0. In Myrmecophaga trigaetyla, Giant Anteater. (Edentata)

E. etrumei Dogiel, 1940 (108). (R) 33.0-36.0 x 33.0-36.0. (Spores) 20.0 x 5.0). In Etrumeus micropus, a marine fish. (Pisces: Isospondyli)

E. eubeckeri Hall and Knipling, 1935 (168). (R) 27.6-40.2 x 21.0-32.4. (M) 33.7 x 23.8. In Citellus franklinii, Franklin's Ground Squirrel. (Rodentia: Sciurinae)

E. exigua Yakimoff, 1934 (470). (M) Oval forms, 15.7 x 12.2; round forms, 13.6 x 13.6. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. (Lagomorpha: Leporinae)

E. exigua var. septentrionalis Madsen, 1938 (268). (R) 21.0-32.0 x 17.0-27.0. (M) 27.0 x 23.0. Synonym of E. septentrionalis Yakimoff, Matschoulsky, and Spartansky, 1936 (524). In Lepus (Lepus) arcticus groenlandicus, East Greenland Hare. (Lagomorpha: Leporinae)

E. falciformis (Eimer, 1870 (115)) Schneider, 1875 (391). (Type species). (M) 26.0 x 16.0. Synonyms: Gregarina falciformis Eimer, 1870 (115); Coccidium falciforme (Eimer, 1870) Schuberg, 1892 (395); Gregarina muris Rivolta, 1878 (375); Pfeifferia schubergi (Labbé, 1896 (220)) Labbé, 1899 (222); Eimeria schubergi (Labbé, 1896 (220)) Doflein, 1916 (107); non Eimeria schubergi (Schaudinn, 1900 (388)). In Mus musculus, House Mouse. (Rodentia: Murinae)

E. falciformis var. criceti Nöller, 1920 (304). (R) 18.0-22.0 x 11.0. In Cricetus cricetus, Common Hamster. (Rodentia: Cricetinae)

E. fanthami Levine, 1953 (257). (R) 18.0-20.1 x 27.0-29.2. (M) 18.8 x 28.3. In Lagopus mutus rupestris, Rock Ptarmigan. (Aves: Galliformes)

E. faurei (Moussu and Marotel, 1902 (296)) Martin, 1909 (275). (R) 30.0-40.0 x 18.0-26.0. Synonyms: Coccidium sp. Moussu and Marotel, 1901 (295); Coccidium faurei Moussu and Marotel, 1902 (296); ? Coccidium caprae Jaeger, 1921 (194); ? Coccidium ovis Jaeger, 1921 (194). In Ovis aries, Domestic Sheep; Rupicapra rupicapra, Chamois; Capra ibex, Ibex; Capra ibex sibirica, Siberian Ibex; Ovis canadensis canadensis, Bighorn Sheep; Ovis musimon, Moufflon; Ovis ammon polii, Ovis ammon sewerzowi, Argali; Ammotragus lervia, Barbary Sheep; Ovis orientalis vignei, Urial or Shapo. (Artiodactyla: Caprinae)

E. fausti Yakimoff and Matschoulsky, 1936 (510). (R) 22.0-24.0 x 12.0 -14.0. In Macropus giganteus, Gray Kangaroo. (Marsupialia: Macropodidae)

E. felina Nieschulz, 1924 (300). (R) 21.0-26.0 x 13.0-17.0. (M) 24.0 x 14.5. In Felis domestica, Domestic Cat; Felis leo, Lion. (Carnivora: Felinae)

E. flavescens Marotel and Guilhon, 1941 (274). (R) 28.0-32.0 x 20.0-22.0. Synonym of E. media? In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. (Lagomorpha: Leporinae)

E. flaviviridis Setna and Bana, 1935 (400). (R) 25.0-34.0 x 11.0-14.0. Synonym: Eimeria sp. Setna, 1933 (398). In Hemidactylus flaviviridis, an Indian gecko. (Reptilia: Sauria)

E. franchini Brunelli, 1935 (29). (M) 17.5 x 9.75. In Sciurus vulgaris var. alpinus, Alpine Squirrel. (Rodentia: Sciurinae)

E. franklinii Hall and Knipling, 1935 (168). (R) 18.6-24.0 x 13.2-18.0. (M) 20.6 x 15.2. In Citellus franklinii, Franklin's Ground Squirrel; Sciurus vulgaris (?). (Rodentia: Sciurinae)

E. fulva Farr, 1953 (123). (R) 20.2-25.2 x 25.6-32.4. (Most frequent) 21.6 x 29.7. In Branta canadensis, Canada Goose; Anser anser (experimental host). (Aves: Anseriformes)

E. furonis Hoare, 1927 (183). (R) 11.2-14.4 x 10.4-12.8. (M) 12.8 x 12.0. In Mustela putorius var. furo, Ferret. (Carnivora: Mustelinae)

E. fusca (Olt, 1896 (310)) Neveu-Lemaire, 1912 (297). Probably not correctly assigned to this genus. (Cf. Hardcastle (171)).

E. gadi Fiebiger, 1913 (126). (R) 26.0-28.0. In Gadus aeglifinis, Haddock; Gadus morrhua, Codfish; Gadus virens, Coalfish. (Pisces: Anacanthini)

E. galli-valeriano. Lapsus for E. galli-valerioi.

E. galli-valerici. Lapsus for E. galli-valerioi.

E. galli-valerioi Rastegaïeff, 1930 (347). (R) 16.2-22.7 x 10.8-14.4. Synonyms: "Eimeria galli-valeriano Rastegaïeff, 1930", lapsus; "Eimeria galli-valerici Rastegaïeff, 1930", lapsus. In Cervus elaphus, Red Deer; Dama dama, Fallow Deer. (Artiodactyla: Cervinae)

E. gallopavonis Hawkins, 1952 (177). (R) 22.2-32.7 x 15.2-19.4. (M) 27.1 x 17.2. In Meleagris gallopavo gallopavo, Domestic Turkey. (Aves: Galliformes)

E. galouzoi Yakimoff and Rastegaïeff, 1930 (527). Considered by Hardcastle (171) to be a synonym of E. parva Kotlán, Mocsy and Vajda, 1929 (208).

E. gambai Carini, 1938 (47). (R) 23.0-28.0 x 18.0-22.0. In Didelphys aurita, South American Opossum. (Marsupialia: Didelphidae)

E. gasterostei (Thélohan, 1890 (426,427)) Doflein, 1909 (106). (R) 16.0-18.0. Synonym: Coccidium gasterostei Thélohan, 1890 (426,427). In Gasterosteus aculeatus; Gasterosteus clupeatus; Sticklebacks. (Pisces: Scleroparei)

E. gekkonis Tanabe, 1928 (424,425). (R) 17.0-20.0 x 13.0-15.0. In Gekko japonicus, a gecko. (Reptilia: Sauria)

E. genettae Agostinucci and Bronzini, 1953 (2). (R) 20.0-30.0 x 12.5-25.0. (M) 25.4 x 19.9. In Genetta dongolana, Genet. (Mammalia: Viverridae)

E. geomydis Skidmore, 1929 (410). (R) 11.6-14.9 x 11.6-13.3. (M) 13.3 x 12.5. In Geomys bursarius, Pocket Gopher. (Rodentia: Geomyinae)

E. gigantea (Labbé, 1896 (220)) Reichenow, 1921 (370). (M) 70.0 x 40.0. Synonyms: Pfeifferia sp. Labbé, 1894 (217); Pfeifferia gigantea Labbé, 1896 (220); Coccidium giganteum Labbé, 1896 (220); Pfeifferella gigantea (Labbé, 1896 (220)) Labbé, 1899 (221). In Lamna cornubica, a shark. (Elasmobranchii)

E. (Globidium) gilruthi (Chatton, 1910 (77, 78)) Reichenow and Carini, 1937 (372). (R) 42.0-60.0 x 30.6-36.0. (M) 45.6 x 33.0. Synonym: Gastrocystis gilruthi Chatton, 1910 (78); E. intricata Spiegl, 1925 (412). In Ovis aries, Domestic Sheep; Capra hircus, Domestic Goat. (Artiodactyla: Caprinae)

E. glaucomydis Roudabush, 1937 (381). (R) 12.3-18.5 x 10.6-13.2. (M) 16.2 x 11.5. In Glaucomys volens, Flying Squirrel. (Rodentia: Petauristinae)

E. globosa (Labbé, 1893 (213)). Synonym of E. tenella.

E. globii Fantham, 1932 (122). (R) 16.8-20.8 x 12.8-16.0. In Gobius nudiceps, Goby. (Pisces: Percomorphi)

E. goussevi Yakimoff, 1935 (472). (M) 21.9 x 15.7. In Talpa europaea, Common Mole (of Europe and Asia). (Insectivora: Talpinae)

E. granulosa Christensen, 1938 (84). (R) 22.0-35.0 x 17.0-25.0. (M) 29.4 x 20.9. In Ovis aries, Domestic Sheep. (Artiodactyla: Caprinae)

E. grobbeni Rudovsky, 1925 (383). (R 10.0-11.0 x 9.0-10.0. In Salamandra atra and Taricha ("Triturus") torosa: salamanders. (Amphibia: Caudata)

E. gruis Yakimoff and Matschoulsky, 1935 (509). (R) 16.2-21.6 x 10.8-14.4. (M) 19.3 x 12.0. Synonym: E. kazanskii Zolotarev, 1937. In Anthropoides ("Grus") virgo, Demoiselle Crane. (Aves: Gruiformes)

E. gubleri (Guiart, 1922 (160)) Wenyon, 1926 (450). Synonym: Coccidium gubleri Guiart, 1922 (160). Very questionable parasite of man.

E. gupti Bhatia, 1938 (18). (M) 36.0 x 18.0. Synonym: Eimeria cylindrica Ray and Das Gupta, 1936 (358); non Eimeria cylindrica Wilson, 1931 (455). In Natrix piscator, an Asiatic Water Snake. (Reptilia: Serpentes)

E. haberfeldi Carini, 1937 (46). (M) 30.0 x 20.0. In Caluromys philander "Quica" or Woolly Opossum. (Marsupialia: Didelphidae)

E. hagani Levine, 1938 (260). (R) 15.8-20.9 x 14.3-19.5. (M) 19.1 x 17.6. In Gallus domesticus, Common Fowl or Chicken. (Aves: Galliformes)

E. hagenmulleri (Léger, 1898 (238)) Levine and Becker, 1933 (258). (M) 17.3 x 13.9. Synonym: Coccidium hagenmulleri Léger, 1898 (238). In Stigmatogaster gracilis, a millipede. (Arthropoda: Diplopoda)

E. halli Yakimoff, 1935 (471). (R) Oval forms, 18.0-32.4 x 12.6-21.6; subspherical forms, 14.0-27.0 x 12.6-24.3; round forms, 18.0-19.8. (M) Oval forms, 24.0 x 17.2. Validity questioned by Hardcastle, 1943 (171). In Rattus norvegicus, Norway Rat, or Brown Rat. (Rodentia: Murinae)

E. harpodoni Setna and Bana, 1935 (399). (M) 14.0 x 14.0. Synonym: Eimeria sp. Setna, 1933. In Harpodon nehereus, Bombay Duck. (Pisces: Iniomi)

? E. hartmanni Rastegaïeff, 1930 (347). (M) 22.8 x 14.4. In Panthera ("Felis") tigris, Tiger. (Carnivora: Felinae)

E. hasei Yakimoff and Gousseff, 1936 (490). (R) Round forms, 12.2-24.4; oval forms, 15.9-19.6 x 12.2-17.1. (M) Round forms, 16.1 x 16.1. In Rattus rattus rattus, Black Rat or House Rat. (Rodentia: Murinae)

E. hegneri Rastegaïeff, 1930 (347). (R) 16.2-18.0 x 10.8-14.4. In Cervus canadensis, Wapiti. (Artiodactyla: Cervinae)

E. hemidactyli Knowles and Das Gupta, 1935 (205). (M) 18.4 x 15.1. In Hemidactylus flaviviridis, an Indian gecko. (Reptilia: Sauria)

E. hemmitraga Yakimoff and Matschoulsky, 1938 (518). Nomen nudum? In hemitragus sp., Thar. (Artiodactyla: Caprinae)

E. hermani Farr, 1953 (124). (R) 17.5-19.5 x 24.3-27.6. (Most frequent) 18.9 x 25.6. In Branta candensis, Canada Goose; Anser anser (experimental host). (Aves: Anseriformes)

E. hessei Lavier, 1924 (230). (R) Round forms, 16.0-20.0; oval forms, 16.0-18.0 x 13.0-15.0. In Rhinolophus hipposideros, Lesser Horseshoe Bat. (Chiroptera: Rhinolophoidea)

E. hemilayanum Ray and Misra, 1942 (364,365). Synonym: Eimeria himalayanum Ray and Misra, 1942. Inadvertent error. (R) 7.0-10.0, the broadest diameter of the rounded oval oocysts. In Bufo himalayanus, Himalayan Toad. (Amphibia: Salientia)

E. hindlei Yakimoff and Gousseff, 1938 (500). (R) 21.9-26.8 x 18.3-20.7. In Mus musculus, House Mouse. (Rodentia: Murinae)

? E. hirsuta Schneider, 1887 (393). (M) 25.0 x 25.0. In Gyrinus natator, a whirligig beetle. (Arthropoda: Insecta)

E. hominis (Rivolta, 1878 (375)). Probably synonym of Isospora belli of man.

E. honessi Landers, 1952 (222). Homonym of Eimeria media form honessi Carvalho, 1943 (66). Synonym of Eimeria punctata Landers, 1955 (223).

? E. hyalina (Léger, 1898 (238)) Reichenow, 1921 (370). (M) 17.0 x 17.0. Synonym: Coccidium hyalinum Léger, 1898 (238). In a beetle. (Arthropoda: Insecta: Coleoptera)

E. hydrochoeri Carini, 1937 (44). (R) 20.0-22.0 x 16.0-18.0. In Hydrochoerus hydrochaerus hydrochaerus, Capybara. (Rodentia: Hydrochoeridae)

E. ictidea Hoare, 1927 (183). (R) 18.4-27.2 x 12.8-20.8. (M) 23.6 x 17.5. In Mustela putorius var. furo, Ferret. (Carnivora: Mustelinae)

E. ildefonsoi Torres and Ramos, 1939 (432). (M) 27.7 x 41.6. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. innocua Moore and Brown, 1952 (291). (R) 18.6-25.9 x 17.3-24.5. (M) 22.4 x 20.9. In Meleagris gallopavo gallopavo, Domestic Turkey. (Aves: Galliformes)

E. innominata Kar, 1944 (196). (M) 17.6 x 13.2. In liver of Lissemys punctata, a pond turtle. (Reptilia: Chelonia)

E. intestinalis Cheissin, 1948 (Sc. J. Karelo-Finskogo Univ., Biol. Sci. 3:179-187). Synonym: Eimeria piriformis Gwéléssiany and Nadiradze, 1945. (R) 21.3-35.9 x 14.6-21.3. (Usual R) 27.1-32.2 x 16.9-19.8. In Oryctolagus ("Lepus") cuniculi, Tame Rabbit. (Lagomorpha: Leporinae)

E. (Globidium) intricata Spiegl, 1925 (412). Synonym of E. (Globidium) gilruthi (Chatton, 1910 (77,78)) Reichenow and Carini, 1937 (372).

E. irara Carini and Fonseca, 1938 (60). (R) 21.0-25.0 x 18.0-20.0. In Tayra barbara, Taira. (Carnivora: Mustelinae)

E. irregularis Kar, 1944 (197). (M) 15.4 x 15.4. In Lissemys punctata, a pond turtle. (Reptilia: Chelonia)

E. irresidua Kessel and Jankiewicz, 1931 (201). (R) 31.0-43.0 x 22.0-27.0. (M) 38.3 x 25.6. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit; Lepus (Macrotolagus) californicus, California Rabbit. (Lagomorpha: Leporinae)

E. irresidua form campanius Carvalho, 1943 (66). "Same morphology and dimensions as E. irresidua." In Lepus (Poecilolagus) townsendii campanius, White-tailed Jack Rabbit. (Lagomorpha: Leporinae).

E. isospora (Savage and Young, 1917 (385)) Wenyon, 1923 (449). Synonym: Coccidium isospora Savage and Young, 1917 (385). (Dobell (fide Magath, 1935 (269)) considered this name to be a misprint or a lapsus calami. Actually, it followed Roche's (1917 (377)) use of "Cocci. isospora".)

E. jaboti Carini, 1942 (58). (M) Round forms, 17.0 x 17.0; oval forms, 17.0-19.0 x 15.0-17.0. In Testudo tabulata, "Jaboti", or South American Tortoise. (Reptilia: Chelonia)

E. jaegeri Carini, 1933 (38). (R) 16.0-18.0 x 16.0-18.0. In Liophis jaegeri, a non-venomous Brazilian snake. (Reptilia: Serpentes)

E. jalina Perroncito, 1901 (316). Probably Blastocystis.

E. johnsoni Yakimoff and Rastegaïeff, 1931 (529). (R) 16.0-27.2 x 14.0-20.4. (M) 21.9 x 17.8. Hardcastle (171) questions validity of this species. In Gallus domesticus, Common Fowl. (Aves: Galliformes)

E. joyeuxi Yakimoff and Gousseff, 1936 (488). (R) 34.5-27.5 x 21.4. (M) 26.4 x 21.4. In Allactaga major (= "A. jaculus"), Jumping hare, Five-toed Jerboa. (Rodentia: Dipodinae)

E. katschkari Yakimoff and Matschoulsky, 1938 (515). Nomen nudum, according to Hardcastle (171). In Ovis ammon polii, Argali. (Artiodactyla: Caprinae)

E. kazanskii Zolotarev, 1937 (536). Synonym of E. gruis, according to Yakimoff, 1940 (477).

E. keilini Yakimoff and Gousseff, 1938 (500). (R) 24.4-31.7 x 18.0-20.7. (M) 28.9 x 19.4. In Mus musculus, House Mouse. (Rodentia: Murinae)

E. kermoganti (Simond, 1901 (407)) Braun, 1908 (27). (R) 20.0-22.0 x 20.0-22.0. Synonym: Coccidium kermoganti. In Gavialis gangeticus, Gharial or Gavial. (Reptilia: Crocodilia)

E. kingi Saxe, 1955 ? (387). (R) 16.1-23.3 x 14.5-20.7. (M) 20.4 x 18.3. In Ambystoma tigrinum, a salamander. (Amphibia: Caudata)

E. knowlesi Bhatia, 1936 (17). (R) 16.0-20.0 x 14.0-18.0. In Hemidactylus flaviviridis, an Indian Gecko. (Reptilia: Sauria)

E. kofoidi Yakimoff and Matikaschwili, 1936 (506). (R) 16.2-25.0 x 14.0-20.0. (M) 20.0 x 17.6. In Alectoris ("Caccabis") chucar, Stone Partridge; Perdix perdix, Gray Partridge. (Aves: Galliformes)

E. koidzumii Matubayas(h)i, 1941 (281). (M) 30.0 x 14.0. In Gecko japonicus, Japanese Gecko. (Reptilia: Sauria)

E. koormae Das Gupta, 1938 (97). (M) 14.0 x 14.0. Synonym: Eimeria boormae Das Gupta, 1938 (97). Lapsus. In Lissemys punctata, an Indian pond turtle. (Reptilia: Chelonia)

E. krijgsmanni Yakimoff and Gousseff, 1938 (500). (R) 18.3-23.2 x 13.4-15.9. In Mus musculus, House Mouse. (Rodentia: Murinae)

E. labbeana Pinto, 1928 (335). (R) 16.0-18.0 x 16.0-18.0. Synonyms: Coccidium pfeifferi Labbé, 1896 (220); Eimeria pfeifferi (Labbé, 1896 (220)) Wasielewski, 1904 (447); non E. pfeifferi (Labbé, 1896 (220)) from Geophilus ferruginosus. In Columba livia, Domestic Pigeon; Streptopelia orientalis meena, a Dove. (Aves: Columbiformes)

E. labbei Hardcastle, 1943 (171). Synonyms: Pfeifferia sp. Labbé, 1894 (217); Pfeifferia tritonis Labbé, 1896 (220); Pfeifferella tritonis (Labbé, 1896 (220)) Labbé, 1899 (221); Eimeria tritonis (Labbé, 1896 (220)) Levine and Becker, 1933 (258); non Eimeria tritonis (Steinhaus, 1891 (419)). In Triton cristatus, a newt. (Amphibia: Caudata)

E. lacazei (Labbé, 1895 (219)) Moroff, 1908 (293). (R) 22.0-25.0. Synonym: Bananella lacazei Labbé, 1895 (219). In Lithobius forficatus, a centipede. (Arthropoda: Chilopoda)

E. lacknowensis. Lapsus for E. lucknowensis.

E. lagopodi Galli-Valerio, 1929 (138). (M) 24.0 x 15.0. In Lagopus mutus, Ptarmigan. (Aves: Galliformes)

E. laminata Ray, 1935 (352,354). (R) 8.0-11.0 x 8.0-11.0. In Bufo melanostictus, an Indian Toad. (Amphibia: Salientia)

E. langeroni Yakimoff and Matschoulsky, 1937 (516). (R) 30.0-36.0 x 16.0-20.0. (M) 32.5 x 18.4. In Phasianus colchicus chrysomelas; Phasianus gordius tschardynensis: pheasants. (Aves: Galliformes)

E. lavieri Yakimoff and Gousseff, 1936 (488). (R) 16.7-18.4 x 16.7-18.4. (M) 17.4 x 17.4. In Allactaga major (="A. jaculus"), Jumping Hare or Five-toed Jerboa. (Rodentia: Dipodinae)

E. legeri (Simond, 1901 (407)) Reichenow, 1921 (370). (R) 16.0-18.0 x 16.0-18.0. Synonym: Coccidium legeri Simond, 1901 (407). In Emyda granosa, a soft-shelled turtle. (Reptilia: Chelonia)

E. legeri (Stankovitch, 1920 (414)). Homonym of E. legeri (Simond, 1901 (407)). Synonym of E. stankovitchi Pinto, 1928 (335), according to Hardcastle (171).

E. leporis Nieschulz, 1923 (299). (R) 26.0-20.0 x 13.0-20.0. (M) 32.0 x 16.0. In Lepus (Lepus) europaeus, European Hare; Lepus (Lepus) timidus, Blue, Mountain, or Varying Hare; Lepus capensis tolae, Tolai Hare. (Lagomorpha: Leporinae)

E. leptodactyli Carini, 1931 (32). (M) 22.0 x 16.0. In Leptodactylus ocellatus, a Frog. (Amphibia: Salientia)

E. (Globidium) leuckarti (Flesch, 1883 (128)) Reichenow, 1940 (371). (R) 80.0-87.5 x 55.0-59.0. Synonym: Globidium leuckarti Flesch 1883 (128). In Equus caballus, Domestic Horse; Equus asinus, Ass. (Perissodactyla: Equidae)

E. longispora Rudovsky, 1922 (382). Size not stated; oocysts inadequately described. In feces of Rupicapra sp., Chamois. (Artiodactyla: Caprinae)

E. lucida (Labbé, 1893 (214)) Reichenow, 1921 (370). (R) 10.0-11.0 x 10.0-11.0. Synonyms: Coccidium lucidum Labbé, 1893 (214); Goussia lucida (Labbé, 1893 (214)) Labbé, 1896 (220). In Acanthias acanthias, Dogfish; Acanthias vulgaris, Spiny Dogfish; Mustelus

vulgaris, Shark; Scyllium catulus; Scyllium stellare. (Elasmobranchii)

E. lucknowensis Misra, 1947 (286). (R) 21.4-24.5 x 17.4-18.8. In Motacilla alba, Wagtail. (Aves: Passeriformes)

E. lyruri Galli-Valerio, 1927 (137). (R) 24.0-27.0 x 15.0. In Lyrurus tetrix, Black Grouse; Perdix ruber; Tetrao urogallus aquitanicus, Capercaillie. (Form found in woodpecker, Dryobates major, by Yakimoff and Gousseff, 1936 (489), becomes E. dendrocopi Levine, 1953 (257). (Aves: Galliformes)

E. maboia Carini, 1938 (47). (R) 17.0-23.0 x 14.0-19.0. (M) 20.0 x 17.0. In Mabuya maboia, a lizard. (Reptilia: Sauria)

E. macieli Yakimoff and Matschoulsky, 1938 (519). (M) 29.7 x 21.2. In Kobus (= Cobus) ellipsiprymnus, Waterbuck. (Artiodactyla: Hippotraginae)

E. macropodis Wenyon and Scott, 1925 (451). (R) 22.0-34.0 x 10.0-17.0. In Macropus bennetti, Bennett's Wallaby. (Marsupialia: Macropodidae)

E. magna Pérard, 1925 (315). (M) 35.0 x 24.0. Synonym: Eimeria perforans var. magna Pérard, 1925 (314). In Oryctolagus ("Lepus") cuniculus, Tame Rabbit and Angora Rabbit; Lepus (Macrotolagus) californicus, California Rabbit; Lepus (Lepus) timidus, Varying Hare; Lepus (Lepus) europaeus, European Hare: Sylvilagus floridanus mearnsi, Mearn's Cottontail (Experimental). (Lagomorpha: Leporinae)

E. magna var. robertsoni Madsen, 1938 (269). Synonym of Eimeria robertsoni Madsen, 1938 (268).

E. magna var. robertsoni forma semisculpta Madsen, 1938 (268). "Similar variation in size" to E. magna var. robertsoni. In Lepus (Poecilolagus) arcticus groenlandicus, East Greenland Hare. (Lagomorpha: Leporinae)

E. magna f. townsendii Carvalho, 1943 (66). "Morphologically similar to E. magna." In Lepus (Poecilolagus) townsendii campanius, White-Tailed Jack Rabbit. (Lagomorpha: Leporinae)

E. magnalabia Levine, 1951 (254). (M) 22.3 x 16.3. In Branta canadensis interior, Canada Goose. (Aves: Anseriformes)

E. maior Honess, 1939 (187). (R) 44.0-51.5 x 26.0-36.5. (M) 46.5 x 30.9. In Sylvilagus nuttallii grangeri, Granger's Cottontail or Wyoming Cottontail"; Sylvilagus floridanus mearnsi. Mearns' Cottontail. (Lagomorpha: Leporinae)

E. malaccae Chakravarty and Kar, 1944 (72). (R) 26.8-30.9 x 16.5-18.5. In Munia malacca malacca, Black-Headed Munia. (Aves: Passeriformes)

E. matsubayashii Tsunoda, 1952 (Exp. Rep. Govt. Sta. Anim. Hyg. Tokyo 25:109-119). (M) 24.8 x 18.2. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit (Lagomorpha: Leporinae)

E. marmotae Galli-Valerio, 1924 (135). (M) 51.0 x 42.0. In Marmota ("Arctomys") marmota, Alpine Marmot. (Rodentia: Sciurinae)

E. marsupialium Yakimoff and Matschoulsky, 1936 (510). (M) 22.2 x 18.0. In Macropus giganteus, Gray Kangaroo. (Marsupialia: Macropodidae)

E. maxima Tyzzer, 1929 (441). (R) 21.5-42.5 x 16.5-29.8. (M) 29.3

x 22.6. In Gallus domesticus, Domestic Fowl; Lophortyx californica vallicola, California Valley Quail (?). (Aves: Galliformes)

E. mayeri Yakimoff, Sokoloff and Matschoulsky, 1936 (533). (R) 16.0-20.0 x 14.0-16.0. (M) 17.4 x 15.3. In Rangifer tarandus, Reindeer. (Artiodactyla: Odocoileini)

E. mazzai Yakimoff and Gousseff, 1934 (481). (R) 16.0-18.0 x 16.0-18.0. In "Frog". (Amphibia: Salientia)

E. mccordocki Landram and Honess, 1955 (Bull. 8, Wyo. Game and Fish Com. pp. 13-19). (R) 33.2-37.3 x 24.9-29.0. (M) 34.8 x 26.6. Synonym: E. mccordocki Honess, 1941 (188). Nomen nudum. In Odocoileus hemionus hemionus, Mule Deer. (Artiodactyla: Odocoileini)

E. media Kessel, 1929 (199). (R) 27.0-36.0 x 15.0-22.0. (M) 31.2 x 18.5. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit; Lepus (Macrotolagus) californicus, California Rabbit; Sylvilagus floridanus mearnsi, Mearns' Cottontail. (Lagomorpha: Leporinae)

E. media form honessi Carvalho, 1943 (66). (R) 24.1-33.2 x 17.0-23.7. (M) 28.2 x 19.6. Synonym: "Variety of E. media" (Honess, 1939 (187)). In Sylvilagus nuttallii grangeri, Granger's Cottontail, "Wyoming Cottontail"; Sylvilagus floridanus mearnsi, Mearns' Cottontail. (Lagomorpha: Leporinae)

E. megalostomata Ormsbee, 1939 (311). (R) 21.0-29.0 x 16.0-22.0. (M) 24.0 x 19.0. In Phasianus colchicus torquatus, Ring-necked pheasant. (Aves: Galliformes)

E. meleagridis Tyzzer, 1927 (440, 441). (R) 19.1-29.7 x 14.5-23.1. (M) 23.8 x 17.3. In Meleagris gallopavo gallopavo, Domestic Turkey; Meleagris gallopavo silvestris, Wild Turkey. (Aves: Galliformes)

E. meleagrimitis Tyzzer, 1927 (440, 441). (R) 16.2-20.5 x 13.2-17.2. (M) 18.1 x 15.3. In Meleagris gallopavo gallopavo, Domestic Turkey; Meleagris gallopavo silvestris, Wild Turkey. (Aves: Galliformes)

E. melis Kotlán and Pospesch, 1933 (209). (R) 17.0-24.0 x 13.0-17.0. (M) 19.0 x 21.0. In Meles meles (="Meles taxus"), (Old World) Badger. (Carnivora: Melinae)

E. mephitidis Andrews, 1928 (9). (R) 17.0-25.0 x 16.0-22.0. (M) 20.7 x 19.2. In Mephitis mephitica, Common Skunk; Mephitis hudsonica, a North American skunk; Mustela putorius, European Polecat. (Carnivora: Mustelinae)

E. meservei Coatney, 1935 (89). (R) 16.2-19.4 x 14.5-18.0. (M) 17.7 x 16.8. In Sterna forsteri, Forster's Tern. (Aves: Charadriiformes)

E. mesnili Rastegaïeff, 1929 (345, 347). (R) 18.0 x 10.8-16.2. In Alopex ("Canis") lagopus, Arctic or Blue Fox. (Carnivora: Caninae)

E. metchnikovi (Laveran, 1897 (224)) Reichenow, 1921 (370). (R) 20.0-25.0 x 20.0-25.0. (Oocysts found within Myxosporidia). Synonym: Coccidium metchnikovi Laveran, 1897 (224). In Gobio fluviatilis, Gudgeon; Gobio gobio, Goby. (Pisces: Percomorphi)

E. mikanii Carini, 1933 (38). (R) 26.0-29.0 x 18.0-20.0. In Sybinomorphus mikanii, a nonvenomous Brazilian snake. (Reptilia: Serpentes)

E. minetti Ray, Raghavachari and Sapre, 1942 (367). (R) 18.0-21.0 x 12.0-14.0. In Mabuya sp., an Indian Lizard. (Reptilia: Sauria)

E. minima Carvalho, 1943 (66). (R) 11.0-15.0 x 9.0-14.0. (M) 13.4 x 10.8. In Sylvilagus floridanus mearnsi, Mearns' Cottontail. (Lagomorpha: Leporinae)

E. minuta (Thélohan, 1892 (428,429)) Doflein, 1909 (106). (R) 9.0-10.0 x 9.0-10.0. Synonyms: Coccodium minutum Thélohan, 1892 (428, 429); Goussia minuta ((Thélohan, 1892) Labbé, 1896 (220). In Tinca vulgaris, Tench; Tinca fluviatilis. (Pisces: Ostariophysi)

E. mira (Lubimov, 1934) Pellérdy, 1934 (Acta Vet. Acad. Sc. Hung. 4:475-480) (R) 30-40 x 19-27. Synonym: Eimeria piriformis Lubimov, 1934. In Sciurus vulgaris, Red Squirrel (Old World). (Rodentia: Sciurinae)

E. mirabilis Yakimoff, 1936 (474). (M) 32.8 x 19.0. In Ophisaurus apodus, "Glass Snake". (Reptilia: Sauria)

E. misgurni Stankovitch, 1924 (416). (R) 15.0-16.0 x 15.0-16.0. In Cobitis taenia, Spiny Loach; Misgurnus fossilia, Loach. (Pisces: Ostariophysi)

E. mitis Tyzzer, 1929 (441). (R) 14.3-19.6 x 13.0-17.0. (M) 16.2 x 15.5. In Gallus domesticus, Common Fowl or Chicken. (Aves: Galliformes)

E. mitraria (Laveran and Mesnil, 1902 (228)) Doflein, 1909 (106). (M) 15.0 x 10.0. In Damonia reevesii, Reeve's Turtle; Chrysemys bellii marginata, Western Painted Terrapin. (Reptilia: Chelonia)

E. miyairii Ohira, 1912 (309). (R) 16.2-26.4 x 13.4-21.3. (M) 22.5 x 17.8. In Rattus norvegicus, Norway or Brown Rat; Rattus rattus rattus, Black or House Rat. (Rodentia: Murinae)

E. mohavensis Doran and Jahn, 1949 (110) (nec 1952). (R) 21.5-26.0 x 14.0-18.5. (M) 24.1 x 15.7. In Dipodomys mohavensis, Kangaroo Rat. (Rodentia: Dipodomyinae)

E. monacis Fish, 1930 (127). (R) 16.8-23.2 x 15.2-21.1. (M) 20.0 x 18.3. (Hardcastle (171) considers E. dura Crouch and Becker, 1931, a synonym; however, the latter name was not actually proposed.) In Marmota monax monax, Woodchuck; Marmota bobak, Bobac or Himalayan Marmot. (Rodentia: Sciurinae)

E. motellae (Labbé, 1893 (214)) Yakimoff, 1929 (457,458). (R) 13.0-14.0 x 13.0-14.0. Synonym: Coccidium motellae Labbé, 1893 (214); Goussia motellae (Labbé, 1893 (214)) Labbé, 1896 (220). In Motella tricirrata, Rockling. (Pisces: Anacanthini)

E. (Globidium) mucosae (Blanchard, 1885 (21)) Nöller, 1920 (305). Synonym of Sarcocystis mucosae (Blanchard, 1885 (21)) Coutelon, 1933 (90, 91, 92); hence, not a coccidium. In Petrogale penicillatus, Rock wallaby. (Marsupialia: Macropodidae)

E. mühlensi Yakimoff, Sokoloff and Matschoulsky, 1936 (533). (R) 32.0 -40.0 x 26.0-28.0. (M) 36.0 x 27.4. In Rangifer tarandus, Reindeer. (Artiodactyla: Odocoileini)

E. muris Galli-Valerio, 1932 (141). (M) 21.0 x 15.0. In Apodemus ("Mus") sylvaticus, Common Field Mouse (Old World). Rodentia: Murinae)

E. musculi Yakimoff and Gousseff, 1938 (500). (M) 20.7 x 25.6. In Mus musculus, House Mouse. (Rodentia: Murinae)

E. mustelae Kingscote, 1934 (202). Homonym of E. mustelae Iwanoff-Gobzem, 1934 (193). Synonym of E. vison Kingscote, 1935 (203).

E. mustelae Iwanoff-Gobzem, 1934 (193). (R) Oval forms, 17.6-26.4 x 15.4-24.2; round forms, 17.6-25.2. (M) Oval forms, 21.6 x 18.8; round forms, 20.2 x 20.2. In Mustela nivalis, Weasel; Mustela vison, Mink. (Carnivora: Mustelinae)

E. mutum Grecchi, 1939 (158, 159). (M) 24.0 x 22.0. In Crax fasciolata, "Mutum", Curassow. (Aves: Galliformes)

E. myopotami Yakimoff, 1933 (463). (R) Round forms, 21.6-23.4; subspherical forms, 21.6-25.2 x 19.8-23.4; oval forms, 21.0-27.0 x 18.0-23.9. (M) Oval forms, 24.0 x 20.4. In Myocastor ("Myopotamus") coypus, Nutria or Coypu. (Rodentia: Capromyidae)

E. myoxi Galli-Valerio, 1940 (144). (M) 18.0 x 15.0. In Eliomys ("Myoxus") quercinus, Garden Dormouse. (Rodentia: Glirinae or Muscardininae)

E. nadsoni Yakimoff and Gousseff, 1936 (489). (R) Spherical forms, 19.5-25.6; subspherical forms, 20.7-29.3 x 17.1-24.4. (M) Spherical forms, 22.1 x 22.1; subspherical forms, 24.9 x 21.3. In Lyrurus tetrix, Black Grouse. (Aves: Galliformes)

E. najae Ray and Das Gupta, 1936 (358). (R) 23.0-27.0 x 16.0-18.0. In Naja naja, Asiatic or Indian Cobra. (Reptilia: Serpentes)

E. nana Marotel and Guilhon, 1941 (274). (R) 15.0-20.0 x 12.0-14.0. Homonym of E. nana Yakimoff, 1933 (464). In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. (Lagomorpha: Leporinae)

E. nana Yakimoff, 1933 (464). From C. sibirica: (R) Oval forms, 16.5-18.0 x 15.0-16.3. (M) Round forms, 15.7. From O. musimon: (R) Round forms, 15.0-18.0 x 15.0-18.0; oval forms, 15.0-18.0 x 9.5-16.0. Synonym of E. parva ? In Capra ibex siberica, Siberian Ibex; Ovis musimon, Mouflon, (Artiodactyla: Caprinae)

E. nasuae Carini and Grechi, 1938 (61). (R) 17.0-19.0 x 15.0-17.0. In Nasua nasica, Coati. (Carnivora: Procyoninae)

(E.) Globidium navillei Harant and Cazal, 1934 (170). (As the describers state, this parasite is probably not an eimerian. If not, it should not have been placed in the genus Globidium.) In Tropidonotus viperinus, an Adder. (Reptilia: Serpentes)

E. naye Galli-Valerio, 1940 (144). (R) 18.0-21.0 x 12.0-13.5. In Apodemus ("Mus") sylvaticus, Common Field Mouse (Old World). Rodentia: Murinae)

E. necatrix Johnson, 1930 (195). (R) 13.2-22.7 x 11.3-18.3. (M) 16.7 x 14.2. In Gallus domesticus, Domestic Fowl or Chicken. (Aves: Galliformes)

E. neglecta Nöller, 1920 (304). (R) 9.0-10.0 x 9.0-10.0. In tadpoles of Rana esculenta and Rana temporaria; frogs. (Amphibia: Salientia)

E. neoleporis Carvalho, 1942 (65). (R) 32.8-44.3 x 15.7-22.8. (M) 38.8 x 19.8. Possible synonym: E. elongata Marotel and Guilhon, 1941 (274). In Sylvilagus floridanus mearnsi, Mearns' Cottontail; Oryctolagus ("Lepus") cuniculus, Tame Rabbit (experimental). (Lagomorpha: Leporinae)

E. neotomae Henry, 1932 (180). (R) 16.0-22.4 x 12.8-19.2. (M) 22.4 x 16.0. In Neotoma fuscipes, Wood Rat. (Rodentia: Cricetinae)

E. nepae Schneider, 1887 (394). Synonym of Barrouxia nepae (Schneider, 1887 (394)) Wenyon, 1926 (450).

E. nicollae Yakimoff and Gousseff, 1935 (484). (M) 26.7 x 16.6. In Carassius carassius. (Pisces: Ostariophysi)

E. nieschulzi Dieben, 1924 (100). (R) 16.2-26.4 x 13.4-21.3. (M) 22.5 x 17.8. Synonym: "Eimeria miyairii Ohira, 1912." In Rattus norvegicus, Norway or Brown Rat; Rattus rattus rattus, Black or House Rat. (Rodentia: Murinae)

E. nicolskii Zolotarev, 1937 (536). Synonym of E. reichenovi, according to Yakimoff, 1940 (477).

E. ninae-kohl-yakimovae Yakimoff and Rastegaïeff, 1930 (527). (R) 18.9-25.4 x 14.4-21.0. (M) 20.7 x 14.8, or 23.0 x 16.1. In Capra hircus, Domestic Goat; Capra ibex sibirica, Siberian Ibex; Ovis aries, Domestic Sheep; Ovis canadensis canadensis, Mountain Sheep; Ovis musimon, Mouflon; Ovis canadensis nivicola, Bighorn Sheep; Ovis orientalis armeniana; Ammotragus lervia, Barbary Sheep; Ovis orientalis arkal, Mouflon; Gazella subgutturosa, Goitred or Persian Gazelle. (Artiodactyla: Caprinae)

E. nishin Fujita, 1934 (131). (R) 45.0-50.0 x 45.0-50.0. In "Herring". (Pisces: Isospondyli)

E. nocens Kotlán, 1933 (207). (R) 25.0-33.0 x 17.0-24.0. In Anser anser anser, Domestic Goose. (Aves: Anseriformes)

E. nochti Yakimoff and Gousseff, 1936 (490). (R) 14.6-24.4 x 12.2-22.0. (M) 17.2 x 14.2. In Rattus rattus rattus, Black or House Rate (Rodentia: Murinae)

? E. nölleri Rastegaïeff, 1930 (347). (M) 18.9 x 18.9. In Cuniculus ("Coelogenus") paca, Lowland Paca. (Rodentia: Dasyproctinae)

E. nölleri Pellérdy, 1956 (313a) (R) 80-800 x 65-80. Synonyms: Globidium cameli Henry and Masson, 1932; Eimeria (Globidium) cameli (Henry and Masson, 1932) Reichenow, 1953. In Camelus bactrianus, Domestic Bactrian Camel. (Artiodactyla: Tylopoda)

E. nonbrumpti Levine, 1953 (257). Synonym: E. yakisevi (= E. brumpti) of the Woodpecker (Dendrocopos major). See E. yakisevi.

E. notopteri Chakravarty and Kar, 1944 (74). (M) 24.2 x 22.0. In Notopterus notopterus, an Indian fish. (Pisces: Isospondyli)

E. nova Schneider, 1881 (392). Synonym of Legerella nova (Schneider, 1881 (392)) Mesnil, 1900 (282).

E. novowenyoni Rastegaïeff, 1929 (345, 347). (R) 14.4 x 18.0. In Panthera ("Felis") tigris, Tiger. (Carnivora: Felinae)

E. nuda (Marcone, 1908 (270)) Levine and Becker, 1933 (258). Probably not a coccidium.

E. nuttalli Yakimoff and Matikaschwili, 1933 (505). (R) 16.5-23.0 x 13.2-16.0. (M) 19.5 x 14.0. In Procyon lotor, Raccoon. (Carnivora: Procyonidae)

E. ondatrae-zibethicae Martin, 1930 (276). (R) 18.8-28.2 x 13.3-26.3. (M) 22.3 x 18.0. In Ondatra zibethicus, Common Muskrat. (Rodentia: Microtinae)

E. ondinae Carini, 1939 (50). (R) 20.0-22.0 x 20.0-22.0. In Drymobius bifossatus, a Brazilian snake. (Reptilia: Serpentes)

E. oryzomysi Carini, 1937 (43). (R) 22.0-25.0 x 17.2. In Oryzomys sp., a Rice Rat. (Rodentia: Cricetinae)

E. os Crouch and Becker, 1931 (93). (R) 20.0-26.0 x 18.0-22.0. In Marmota monax monax, Groundhog or Woodchuck. (Rodentia: Sciurinae)

E. ostertagia Yakimoff and Gousseff, 1936 (496). (R) 26.8-41.5 x 22.0-

36.7. (M) 33.1 x 26.5. In Erinaceus europaeus, European Hedgehog. (Insectivora: Erinaceidae)

E. oviformis (Leuckart, 1879 (250)). Synonym of Coccidium oviforme, Leuckart, 1879 (250), and E. stiedae (Lindemann, 1865 (263)).

E. oxyphila. Lapsus for E. oxyspora Dobell, 1919 (104).

E. oxyspora Dobell, 1919 (103). Synonym: E. sardinae Thélohan, 1890 (427).

E. pacifica Ormsbee, 1939 (311). (R) 17.0-26.0 x 14.0-20.0. (M) 22.0 x 18.0. In Phasianus colchicus torquatus, Ring-Necked Pheasant. (Aves: Galliformes)

E. pallida Christensen, 1938 (84). (R) 12.0-20.0 x 8.0-15.0. (M) 14.2 x 10.0. In Ovis aries, Domestic Sheep. (Artiodactyla: Caprinae)

E. paludosa (Léger and Hesse, 1922 (245)) Hoare, 1933 (184). (R) 14.0-15.0 x 11.0. Synonym: Jarrina paludosa Léger and Hesse, 1922 (245). In Fulica atra atra, Coot; Fulica americana, American Coot; Gallinula chloropus chloropus, Moor Hen. (Aves: Gruiformes)

E. paraensis Carini, 1935 (39). (R) 33.0-40.0 x 30.0-35.0. In Aguti aguti, "Cotia vermelha" or red agouti. (Rodentia: Dasyproctinae)

E. parva Kotlán, Mocsy and Vajda, 1929 (208). (R) 11.4-14.3 x 9.5-11.8. Synonym: Eimeria galouzoi Yakimoff and Rastegaïeff, 1930 (527). In Ovis aries, Domestic Sheep; Capra hircus, Domestic Goat; Capra ibex sibirica, Siberian Ibex; Ovis canadensis canadensis, Rocky Mountain Sheep; Ovis canadensis nivicola, Bighorn Sheep; Ammotragus lervia, Barbary Sheep. (Artiodactyla; Caprinae)

E. parvula Kotlán, 1933 (207). (R) 10.0-15.0 x 10.0-14.0. Synonym: Eimeria anseris Kotlán, 1932 (206), pro parte. In Anser anwer anser, Domestic Goose. (Aves: Anseriformes)

E. pattersoni Honess and Post, 1955 (189a). (R) 17.8-22.6 x 11.8-15.1. (M) 20.2 x 13.5. In Centrocercus urophasianus, Sage Grouse. (Aves: Galliformes)

E. paulistana da Fonseca, 1934 (130). (R) 40.0-43.0 x 23.5. In Sylvilagus (Silvilagus) brasiliensis minensis, "Coelho do Matto" or Brazilian Hare." (Lagomorpha: Leporinae)

E. pellita Supperer, 1952 (423). (R) 36.2-40.9 x 26.5-30.2. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. pellucida Yakimoff, 1933 (463). (R) 30.0-39.6 x 19.8-23.4. In Myocastor ("Myopotamus") coypus, Nutria or Coypu. (Rodentia; Capromyidae)

E. perardi Yakimoff and Gousseff, 1936 (496). (R) 17.1-27.0 x 14.6-15.9. (M) 20.0 x 15.0. In Erinaceus europaeus, European Hedgehog. (Insectivora: Erinaceidae)

E. percae (Dujarric de la Rivière, 1914 (114)) Reichenow, 1921 (370). Synonym: Coccidium percae Dujarric de la Rivière, 1914 (114). In Perca fluviatilis, Perch. (Pisces: Percomorphi)

E. perforans (Leuckart, 1879 (250)) Sluiter and Swellengrabel, 1912 (411). (R) 15.0-30.0 x 11.0-20.0. (M) 21.5 x 15.5. In Oryctolagus ("Lepus") cuniculi, Tame Rabbit; Lepus (Poecilolagus) americanus, Varying Hare: Lepus (Lepus) arcticus groenlandicus, East Greenland Hare; Lepus (Macrotolagus) californicus, California Jack Rabbit; Lepus (Lepus) europaeus, European Hare; Silvilagus

(Silvilagus) brasiliensis minensis, "Coelho do Matto" or "Brazilian Hare"; Silvilagus floridanus mearnsi, Mearns' cottontail (experimental). (Lagomorpha: Leporinae)

E. perforans var. groenlandica Madsen, 1938 (268). (R) 23.0-40.0 x 17.0-27.0. (M) 32.6 x 22.3. In Lepus (Lepus) arcticus groenlandicus, East Greenland Hare. (Lagomorpha: Leporinae)

E. perforans var. stiedae Doria, 1933 (R) 25-36 x 21. In "Coniglio". (Lagomorpha: Leporinae)

E. perforoides Crouch and Becker, 1931 (93). (R) 17.0-24.0 x 15.0-20.0. In Marmota monax monax, Groundhog or Woodchuck. (Rodentia: Sciurinae)

? E. perichaetae (Beddard, 1888 (14)) Levine and Becker, 1933 (258). Synonym: Coccidium perichaetae Beddard, 1888 (14). In Perichaeta armata; Perichaeta novae-zelandiae. (Annelida: Oligochaetae)

E. perminuta Henry, 1931 (178). (R) 11.2-16.0 x 9.6-12.8. Synonym: Eimeria permunita Henry, 1931 (178). Lapsus. In Sus scrofa domestica, Domestic Pig. (Artiodactyla: Suiformes)

E. permunita. Lapsus for E. perminuta Henry, 1931 (178).

E. persica (Phisalix, 1925 (328)) Levine and Becker, 1933 (258). (M) 31.5 x 18.9. Synonym: Coccidium persicum Phisalix, 1925 (328). In Natrix natrix var. persa, a Grass Snake. (Reptilia: Serpentes)

E. peruviana Yakimoff, 1934 (469). (R) 27.8-37.5 x 18.0-22.5. (M) 31.8 x 19.3. In Lama glama, Llama. (Artiodactyla: Tylopoda)

E. (Globidium) petauristae Ray and Singh, 1949 (368, 369). (R) 46.3-52.5 x 35.0-40.4. In Petaurista petaurista (="P. inornatus"). Common Giant Flying Squirrel. (Rodentia: Petauristinae)

E. pfeifferi (Labbé, 1896 (220)). Synonym: Coccidium pfeifferi Labbé, 1896 (220). In Geophilus ferruginosus, a centipede. (Arthropoda: Chilopoda)

E. pfeifferi (Labbé, 1896 (220)). Homonym of E. pfeifferi (Labbé, 1896 (220)). Synonym of E. labbeana Pinto, 1928 (335).

E. phasiani Tyzzer, 1929 (441). (R) 19.8-26.4 x 13.2-17.8. (M) 23.0 x 15.9. In Phasianus cholchicus torquatus, Ring-Necked Pheasant; Phasianus colchicus colchicus, English Pheasant. (Aves: Galliformes)

E. phyllotis Gonzáles-Mugaburu, 1942 (149). (R) 22.2-30.2 x 12.2-15.8. (M) 26.2 x 14.0. In "Phyllotis amicus amicus". (Rodentia: Cricetinae)

E. pigra Léger and Bory, 1932 (242). (R) 17.0-19.0 x 14.0. In Scardinius erythrothalmus, Red Roach. (Pisces: Ostariophysi)

E. pintoensis da Fonseca, 1933 (129). (R) 23.0-26.5 x 15.0-16.0. In Sylvilagus (Silvilagus) brasiliensis minensis, "Coelho do Matto" or "Brazilian Hare". (Lagomorpha: Leporinae)

E. pintoi Carini, 1932 (33). (R) 30.0-33.0 x 20.0-22.0. In Crocodilus sp., "Cayman". (Reptilia: Crocodilia)

E. piraudi Gauthier, 1921 (145). (R) 11.0-13.0 x 11.0-13.0. In Cottus gobio, "Bullhead". (Pisces: Scleroparei)

E. piriformis Gwéléssiany and Nadiradze, 1945 (Trudy Gruzinskoi Nauk, Vet. Station 9). Homonym of E. piriformis Kotlán and Pospesch, 1934 and E. piriformis Marotel and Guilhon, 1941. Synonym of E. intestinalis Cheissin, 1948.

E. piriformis Kotlán and Pospesch, 1934 (210). (M) 29.0 x 18.0. In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. (Lagomorpha: Leporinae). In Sciurus vulgaris, Red Squirrel (Old World). (Rodentia: Sciurinae)

E. piriformis Marotel and Guilhon, 1941 (274). (R) 25.0-30.0 x 15.0-18.0. Homonym of E. piriformis Kotlán and Pospesch, 1934 (210). In Oryctolagus ("Lepus") cuniculus, Tame Rabbit. Lagomorpha: Leporinae)

E. piscatori Ray and Das Gupta, 1936 (358). (R) 29.0-31.0 x 22.5-24.5. In Natrix piscator, an Asiatic water snake. (Reptilia: Serpentes)

E. poccilogyri. Lapsus for E. poecilogyri.

E. poecilogyri Carini, 1933 (38). (R) 15.0-16.0 x 15.0-16.0. Synonym: Eimeria poccilogyri Carini, 1933 (38). Lapsus. In Leimadophis poecilogyrus, a nonvenomous snake. (Reptilia: Serpentes)

E. polaris Yakimoff and Sokoloff, 1935 (532). (R) 24.0-34.5 x 15.0-24.0. (M) 27.2 x 17.7. In Rangifer tarandus, Reindeer. (Artiodactyla: Odocoileini)

E. polita Pellérdy, 1949 (313). (R) 23.0-27.0 x 18.0-21.0. In Sus scrofa domestica, Domestic Pig. (Artiodactyla: Suiformes)

E. polycephali Yakimoff and Matschoulsky, 1939 (521). (M) 17.3 x 13.9. In Porphyrio ("Polycephalus") caeruleus, a Rail. (Aves: Gruiformes)

E. ponderosa Wetzel, 1942 (453). (R) 37.8-45.0 x 25.2-28.8. (M) 39.6 x 27.0. In Capreolus capreolus, Roe Deer. (Artiodactyla: Odocoileini)

E. praecox Johnson, 1930 (195). (R) 19.8-24.7 x 15.7-19.8. (M) 21.3 x 17.1. In Gallus domesticus, Domestic Fowl or Chicken. (Aves: Galliformes)

E. prevoti (Laveran and Mesnil, 1902 (226)) Doflein, 1909 (106). (R) Usual forms, 20.0-22.0 x 12.0-15.0. (M) Subspherical forms, 18.0 x 16.0. Synonyms: Paracoccidium prevoti Laveran and Mesnil, 1902 (228); Eimeria prevunti Laveran and Mesnil, 1902 (226), lapsus. In Rana esculenta, a frog. (Amphibia: Salientia)

E. prevunti. Lapsus for E. prevoti.

E. princeps (Labbé, 1894 (216)) Walton, 1941 (445); nec Levine and Becker, 1933. Walton (445) lists this species originally designated Drepanidium princeps with the Eimeriidae of Amphibia, but Wenyon (450), following Nöller, considers it to be a synonym of Lankesterella minima (Chaussat, 1850 (82)).

E. princeps (Labbé, 1896 (220)) Levine and Becker, 1933 (258). Nomen nudum. In a rabbit.

E. procera Haase, 1939 (164). (R) 28.8-31.2 x 16.4-17.2. In Perdix perdix Gray Partridge; Tetrao urogallus, Heath Cock. (Aves: Galliformes)

E. propria (Schneider, 1881 (392)) Doflein, 1909 (106). (R) 36.0-43.0 x 20.0-27.0. Synonyms: Orthospora propria Schneider, 1881 (392); Coccidium proprium (Schneider, 1881) Schneider, 1887 (394). In Molge hagenmulleri; Salamandra salamandra; Triturus cristatus; T. palmatus; T. helveticus; T. alpestris; T. pyrrhogaster; T. marmoratus; T. vulgaris; newts. (Amphibia: Caudata)

E. punctata Landers, 1955 (223). Synonym: E. honessi Landers, 1952 (222). (M) 21.2 x 17.7. In Ovis aries, Domestic Sheep. (Artiodactyla: Caprinae)

E. pylori (Gebhardt, 1897 (146)) Levine and Becker, 1933 (258). Egg of Distomum turgidum, according to Braun, 1908 (27). In Rana sp. (Amphibia: Salientia)

E. pythonis Triffitt, 1925 (434). (R) 17.0-36.0 x 11.5-21.0. (M) 27.5 x 17.0. In Python sebae; Python molurus; pythons. (Reptilia: Serpentes)

E. raiarum van den Berghe, 1937 (15). (M) 22.0 x 20.0. In Raja batis, a ray. (Elasmobranchii)

E. railieti (Léger, 1899 (239)) Galli-Valerio, 1930 (139). (M) 18.0 x 18.0. Synonym: Coccidium raillieti Léger, 1899 (239). In Anguis fragilis, Blindworm. (Reptilia: Sauria)

E. ranae (Dobell, 1908 (101)) Dobell, 1909 (102). (R) 18.0-22.0 x 18.0-22.0. Synonym: Coccidium ranae Dobell, 1908 (101). In Rana esculenta and Rana temporaria: frogs. (Amphibia: Salientia)

E. ranarum (Labbé, 1894 (217)) Doflein, 1909 (106). (M) 17.0 x 12.0 vide Laveran and Mesnil, 1902 (226)). Synonyms: Karyophagus ranarum Labbé, 1894 (217); Coccidium ranarum (Labbé, 1894 (217)) Laveran and Mesnil, 1902 (226); Acystis parasitica Labbé, 1894 (217), pro parte. In Rana esculenta and Rana temporaria: frogs; Ambystoma opacum (according to Walton (445)). (Amphibia: Salientia and Caudata, resp.)

E. ratti Yakimoff and Gousseff, 1936 (490). (R) 15.9-28.1 x 14.6-15.9. (M) 22.8 x 14.7. In Rattus rattus rattus, Black Rat or House Rat. (Rodentia: Murinae)

E. reichenovi Yakimoff and Matschoulsky, 1935 (509). (R) 14.0-23.4 x 12.6-18.0. (M) 18.5 x 13.6. Synonym: E. nicolskii. In Anthropoides ("Grus") virgo, Demoiselle Crane. (Aves: Gruiformes)

E. residua Henry, 1932 (180). (R) 22.4-28.8 x 19.2-25.6. (M) 25.6 x 22.4. In Neotoma fuscipes, Wood Rat. (Rodentia: Cricetinae)

E. rhynchoti Reis and Nobrega, 1936 (373). (R) 19.3-29.7 x 17.0-25.5. (M) 24.9 x 22.3. In Rhynchotus rufescens, "Codorna", "Perdiz" or Tinamou. (Aves: Tinamiformes)

E. riedmülleri Yakimoff and Matschoulsky, 1940 (522). (M) 19.6 x 16.8. In Rupicapra rupicapra, Chamois. (Artiodactyla: Caprinae)

E. rivierei Yakimoff, 1929 (457). (R) Round forms, 14.0-16.8 x 14.0-16.8; oval forms, 11.6-15.5 x 7.0-13.3. In Perca fluviatilis, Common Perch. (Pisces: Percomorphi)

E. rivolta Grassi, 1879 (157). Synonym of Isospora rivolta (Grassi, 1879 (157)) Dobell, 1919 (104).

E. rivoltae (Harz, 1887 (173)). Nomen nudum. In chickens and other birds.

E. robertsoni Madsen, 1938 (268). (R) 34.0-52.0 x 23.0-32.0. (M) 42.1 x 25.8. Synonym: Eimeria magna var. robertsoni (Madsen, 1938 (268)). In Lepus (Lepus) arcticus groenlandicus, East Greenland Hare; Lepus (Poecilolagus) townsendii campanius, White-Tailed Jack Rabbit. (Lagomorpha: Leporinae)

E. rocha-limai Carini and Pinto, 1926 (62, 63). In gall bladder and bile ducts of Hemidactylus mabuia, a South American Gecko; Ameiva ameiva, a New World Lizard. (Reptilia: Sauria)

E. roscoviensis (Labbé, 1893 (213)) Wasielewski, 1904 (447). (R) 16.0-18.0 x 14.0-16.0. Synonym: Coccidium roscoviense Labbé, 1893

(213). In Actitis hypoleucos; Calidris arenaria; Charadrius alexandrinus; C. cantianus; C. dubius; C. philippinus; Numenius phaeopus; Pelidna torquata; Pluvialis apricarius; Strepsilas interpres; Totanus calidris; T. hypoleucos; T. totanus totanus; Tringa alpina. (Aves: Charadriiformes) In Motacilla alba. (Aves: Passeriformes) In Phalacrocorax aristotelis. (Aves: Pelecaniformes)

E. rotunda Pellérdy, 1955 (Acta Vet. Acad. Sci. Hung. 5:161-166). (R) 11.0-14.0. In Capreolus capreolus, Roe Deer. (Artiodactyla: Odocoileinae)

E. rouxi (Elmassian, 1909 (116)) Reichenow, 1921 (370). (M) 10.0-12.0 x 10.0-12.0. Synonym: Coccodium rouxi Elmassian, 1909 (116). In Tinca tinca; Tinca vulgaris; both tenches; Cyprinus carpio, Carp. (Pisces: Ostariophysi)

E. rugosa Pellérdy, 1954 (Acta Vet. Acad. Sc. Hung. 4:187-191). (R) 23.0-27.0 x 15.0-19. In Apodemus flavicollis. Waldmaus (=Woods Mouse). (Rodentia: Murinae)

E. rupicaprae Galli-Valerio, 1923 (134). (M) 21.0 x 16.5. In Rupicapra rupicapra, Chamois. (Artiodactyla: Caprinae)

E. salamandrae (Steinhaus, 1889 (418)) Dobell, 1909 (102). Synonyms: Karyophagus salamandrae Steinhaus, 1889 (418); Cytophagus tritonis Steinhaus, 1891 (419); Acystis parasitica Labbé, 1894 (217), pro parte; Karyophagus tritonis (Steinhaus, 1891 (419)) Wasielewski, 1896 (446); Coccidium salamandrae (Steinhaus, 1889 (418)) Simond, 1897 (406); Eimeria tritonis (Steinhaus, 1891 (419)) Walton, 1941 (445). In Salamandra salamandra (="Salamandra maculosa"), a salamander. (Amphibia: Caudata)

E. salamandrae atrae (Phisalix, 1927 (330)) Levine and Becker, 1933 (258). (M) 27.5 x 23.0. Synonym: Coccidium salamandrae atrae Phisalix, 1927 (330). In Salamandra atra, a salamander. (Amphibia: Caudata)

E. sardinae (Thélohan, 1890 (427)) Reichenow, 1921 (370). (M) 50.0 x 50.0. Synonyms: Coccidium sardinae Thélohan, 1890 (427); Eimeria oxyphila Dobell, 1919 (103), lapsus; Eimeria oxyspora Dobell, 1919 (103; Eimeria snijdersi Dobell, 1920 (104). In Clupea pilchardus, Sardine; "Herring"; "Mackerel". (Pisces: Isospondyli)

E. scabra Henry, 1931 (178). (R) 22.4-35.6 x 16.0-25.6. Synonym: Eimeria scarba Henry, 1931 (178), lapsus. In Sus scrofa domestica, Domestic Pig; Sus scrofa scrofa, Wild Boar. (Artiodactyla: Suiformes)

E. scapani Henry, 1932 (180). (R) 16.0-22.4 x 14.4-16.0. (M) 19.2 x 16.0. In Scapanus latimanus, California Mole; Talpa micrura coreana (="Mogera wogura coreana"), Eastern Mole. (Insectovora: Talpidae)

E. scarba. Lapsus for E. scabra Henry, 1931 (178).

E. schaudinniana Pinto, 1928 (335). Synonyms: Coccidium schubergi Schaudinn, 1900 (388); Eimeria schubergi (Schaudinn, 1900 (388)) Wasielewski, 1904 (447); non Eimeria schubergi (Labbé, 1896 (220)). In Lithobius forficatus, a Centipede. (Arthropoda: Chilopoda)

E. schneideri Bütschli, 1881 (30). Synonym of Barrouxia schneideri (Bütschli, 1881 (30)) Labbé, 1899 (221).

E. schubergi (Labbé, 1896 (220)). Synonym of E. falciformes Eimer, 1870 (115).

E. schubergi Schaudinn, 1900 (388). Homonym of E. schubergi (Labbé, 1896 (220)). Synonym of E. schaudinniana Pinto, 1928 (335).

E. schüffneri Yakimoff and Gousseff, 1938 (500). (R) 18.3-24.3 x 14.6-15.5. In Mus musculus, House Mouse. (Rodentia: Murinae)

E. scinci (Phisalix, 1923 (320, 322)) Levine and Becker, 1933 (258). (R) 31.0-35.0 x 18.0-20.0. Synonyms: Coccidium scinci (Phisalix, 1923 (320, 322)); Eimeria sinci Phisalix, 1923 (320, 322), lapsus. In Scincus officinalis, Egyptian Skink; Hemidactylus flaviviridis, An Indian gecko. (Reptilia: Sauria)

E. sciuri. Lapsus for E. sciurorum Galli-Valerio, 1922 (133).

E. sciurorum Galli-Valerio, 1922 (133). (M) 24.0 x 15.0. In Sciurus vulgaris var. alpinus, Alpine Squirrel; Sciurus carolinensis, Gray Squirrel; Sciurus niger rufiventer, Fox Squirrel; Glaucomys volans, Eastern Flying Squirrel. (Rodentia: Sciurinae)

E. scrofae Galli-Valerio, 1935 (143). (M) 24.0 x 15.0. In Sus scrofa domestica, Domestic Pig. (Artiodactyla: Suiformes)

E. sculpta Madsen, 1938 (268). (R) 32.0-42.0 x 23.0-32.0. (M) 36.8 x 28.8. In Lepus (Lepus) arcticus groenlandicus, East Greenland Hare; Lepus (Poecilolagus) townsendii campanius, White-Tailed Jack Rabbit. (Lagomorpha: Leporinae)

E. scylii (Drago, 1902 (113)) Levine and Becker, 1933 (260). Synonym: Coccidium scylii Drago, 1902 (258). In Scyllium sp., a dogfish. (Elasmobranchii)

E. separata Becker and Hall, 1931 (12). (R) 12.8-19.4 x 11.2-17.2. (M) 16.1 x 13.9. In Rattus norvegicus, Norway or Brown Rat. (Rodentia: Murinae)

E. septentrionalis Yakimoff, Matschoulsky and Spartansky, 1936 (524). (R) 24.0-32.0 x 20.0-22.0. (M) 26.7 x 21.6. In Lepus (Lepus) timidus, Alpine Hare: Lepus (Lepus) arcticus groenlandicus, East Greenland Hare; Lepus (Lepus) townsendii campanius, White-Tailed Jack Rabbit. (Lagomorpha: Leporinae)

E. sibirica Yakimoff and Terwinsky, 1931 (535). (R) 21.3-27.6 x 17.0-21.3. (M) 24.3 x 19.5. In Martes zibellina, Sable. (Carnivora: Mustlinae)

E. silvana Pellérdy, 1954 (Acta Vet. Acad. Sc. Hung. 4:475-480). (R) 15.0-18.0 x 12.0-15.0. In Sciurus vulgaris, Red Squirrel (Old World). (Rodentia: Sciurinae)

E. simondi (Léger, 1898 (238)) Levine and Becker, 1933 (258). Synonym: Coccidium simondi Léger, 1898 (238). In Himantarium gabrielis, a centipede. (Arthropoda: Chilopoda)

E. sinci. Lapsus for E. scinci.

E. smithi Yakimoff and Galouzo, 1927 (480). Synonym of E. bovis.

E. snijdersi Dobell, 1920 (104). Synonym of E. sardinae.

E. solipedum Gousseff, 1934 (151). (R 15.5-28.0 x 15.0-28.0. In Equus caballus, Domestic Horse; also, Ass and Mule. (Perissodactyla: Equidae)

E. somateriae Christansen, 1952 (87). (R) 21.0-41.0 x 11.0-19.0. In Somateria mollisima, Common Eider. (Aves: Anseriformes)

E. soricinae Galli-Valerio, 1927 (137). (M) 50.0 x 30.0. In Sorex araneus, Common Shrew. (Insectivora: Soricidae)

E. soricis Henry, 1932 (180). (R) 19.2-22.4 x 12.8-14.4. (M) 19.2 x

14.4. In Sorex araneus, Common Shrew; Sorex californicus, California Shrew. (Insectivora: Soricidae)

E. sontlae. Lapsus for E. souflae.

E. souflae Stankovitch, 1921 (415). (R) 17.0-18.0 x 17.0-18.0. Synonym: Eimeria sontlae Stankovitch, 1921 (415), lapsus. In Squalius agassizi. (Pisces: Ostariophysi)

E. southwelli Halawini, 1930 (167). (M, sporulated) 38.0 x 12.0. Polymorphic. In Aetobatis narinari, Devil Fish. (Elasmobranchii)

E. speotytoi Carini, 1939 (51). (R) 32.0-34.0 x 24.0-26.0. In Speotyto cunicularia grallaria, an owl. (Aves: Strigiformes)

E. sphenocercae D.K. Ray, 1952 (348). (R) 25.0 x 12.5-15.0. (M) 19.2 x 12.6. In Sphenurus ("Sphenocercus") sphenurus, Kokla Green PIgeon. (Aves: Columbiformes)

E. spherica (Schneider, 1887 (394)) Levine and Becker, 1933 (258). (M) 22.0-38.0. Synonyms: Coccidium sphericum Schneider, 1887 (394); Cytophagus tritonis Steinhaus, 1891 (419). (Cf. Matubayasi, 1937 (280)). In Triturus alpestris. T. cristatus; T. helveticus; T. vulgaris; T. pyrrhogaster: newts. (Amphibia: Caudata)

E. spinosa Henry, 1931 (178). (R) 16.0-22.4 x 12.8-16.0. In Sus scrofa domestica, Domestic Pig. (Artiodactyla: Suiformes)

E. sprehni Yakimoff, 1934 (468). (M) 17.6 x 12.0. In Castor canadensis canadensis, North American Beaver; Castor fiber, European Beaver. (Rodentia: Castorinae)

E. stankovitchi Pinto, 1928 (335). (M) 10.0 x 10.0. Synonyms: Goussia légeri Stankovitch, 1920 (414); Eimeria légeri (Stankovitch, 1920 (414)) Pinto, 1928 (335); non Eimeria légeri (Simond, 1901 (408)). In Alburnus brama, Bream; Alburnus lucidus, Small Bleak; Scardinius erythrothalmus, Red Roach. (Pisces: Ostariophysi)

E. stenocerci Carini, 1940 (54). (R) 24.0-27.0 x 19.0-20.0. Synonym: E. tropiduri Carini, 1941 (55). In Tropidurus torquatus torquatus, a Brazilian lizard, nec Stenocercus sp. (Reptilia: Sauria)

E. stercorariae Galli-Valerio, 1940 (144). (M) 12.0 x 9.0. In Stercorarius parasiticus. (Aves: Charadriiformes)

E. steidae (Lindemann, 1865 (263)) Kisskalt and Hartmann, 1907 (204). (R) 28.0-42.0 x 16.0-25.0. (M) 36.9 x 19.9. Synonyms: Monocystis stiedae Lindemann, 1865 (263); ? Psorospermium cuniculi Rivolta, 1878 (375); Coccidium oviforme Leuckart, 1879 (250); ? Coccidium cuniculi (Rivolta, 1878 (375)) Labbé, 1899 (221); ? Eimeria cuniculi (Rivolta, 1878 (375)) Wasielewski, 1904 (447); Eimeria oviformis (Leuckart, 1879 (250)) Fantham, 1911 (120). In Oryctolagus ("Lepus") cuniculus, Tame Rabbit; Lepus (Lepus) europeus, European Hare; Lepus (Poecilolagus) americanus, Varying Hare; Lepus (Macrotolagus) californicus, Black-Tailed or California Jack Rabbitt; Lepus (Lepus) timidus, Alpine Hare; Lepus variabilis; Sylvilagus floridanus mallurus; Silvilagus floridanus mearnsi, Mearns' Cottontail; Silvilagus nuttalli grangeri, "Wyoming Cottontail". (Lago: Leporinae)

E. stiedae var. cuniculi Graham, 1933 (154). Synonym of Eimeria stiedae. In "rabbit", presumably Tame Rabbit. (Lagomorpha: Leporinae)

E. stolatae Ray and Das Gupta, 1938 (363). (M) 20.5 x 20.5. In Natrix

stolata, Indian Grass Snake or Striped Keelback. (Reptilia: Serpentes)

E. striata Farr, 1953 (123). (R) 13.7-18.0 x 18.9-23.6. (Most frequent) 15.5-17.5 x 20.2-22.9. In Branta canadensis, Canada Goose or "Brant"; Anser Anser (experimental host).

E. subepithelialis Moroff and Fiebiger, 1905 (294). (M) 18.0-22.0 x 18.0-22.0. In Cyprinus carpio, Carp. (Pisces: Ostariophysi)

E. subrotunda Moore, Brown, and Carter, 1954 (292). (R) 16.5-26.4 x 14.2-24.4. (M) 21.8 x 19.8. In Meleagris gallopavo gallopavo, Domestic Turkey. (Aves: Galliformes)

E. subspherica Christensen, 1941 (85). (R) 9.0-13.0 x 8.0-12.0. (M) 11.0 x 10.4. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. suis Nöller, 1921 (306). Synonym of E. debliecki.

E. superba Pellérdy, 1955 (Acta Vet. Acad. Sc. Hung. 5:161-166). (R) 43-50 x 30-34. In Capreolus capreolus, Roe Deer. (Artiodactyla: Odocoileinae)

E. silvilagi Carini, 1940 (53). (R) 26.0-28.0 x 15.0-16.0. In Silvilagus (Silvilagus) brasiliensis minensis, "Brazilian Hare". (Lagomorpha: Leporinae)

E. syngnathi Yakimoff and Gousseff, 1936 (491). (R) 24.5-32.0 x 16.7-24.5. (M) 28.7 x 20.6. In Sygnathus nigrolineatus, Great Pipe Fish. (Pisces: Solenichthyes)

E. tarandina Yakimoff, Sokoloff and Matschoulsky, 1936 (533). (R) Oval forms, 18.0-24.0 x 16.0-22.0; round forms, 18.0-29.0. (M) Oval forms, 20.1 x 17.7; round forms, 20.0 x 20.0. In Rangifer tarandus, Reindeer. (Artiodactyla: Odocoileini)

E. tatusi Carini, 1933 (37). (R) 30.0-33.0 x 30.0-33.0. Homonym of E. (Globidium tatusi Cunha and Torres, 1926 (384), if the latter is actually a coccidium. In Cabassus sp., Tatu; Cabassus unicinctus, Tatu; Chaetophractus villosus. (Edentata: Cingulata)

E. (Globidium) tatusi (Cunha and Torres, 1926 (96)). (Described from schizonts which, according to Reichenow and Carini, 1937 (372), correspond imperfectly with similar stages of E. (Globidium) travassosi.) In Tatus novemcinctus, an armadillo. (Edentata: Cingulata)

E. tenella (Railliet and Lucet, 1891 (343)) Fantham, 1909 (119). (R) 19.6-26.1 x 16.3-22.8. (M) 22.6 x 19.0. Synonyms: Eimeria avium auct.; Coccidium tenellum Railliet and Lucet, 1891 (343); ? Coccidium globosum Labbé, 1893 (213); Eimeria bracheti Gérard, 1913 (147); ? Eimeria globosa (Labbé, 1893 (213)) Levine and Becker, 1933 (258). In Gallus domestica, Common Fowl or Chicken. Other Galliformes are listed by Hardcastle (171) but the identification of the parasite as E. tenella has not been proved. (Aves: Galliformes)

E. tertia Lavier, 1936 (232). (R) 22.0-33.0 x 18.0-25.0. (M) 26.0 x 21.0. In Triturus alpestris, a newt. (Amphibia: Caudata)

E. tetricis Haase, 1939 (164). (R) 29.8-31.4 x 14.2-15.4. In Lyrurus ("Tetrao") tetrix, Black Grouse. (Aves: Galliformes)

E. thélohani (Labbé, 1896 (220)) Yakimoff, 1929 (457). (R) 25.0-30.0 x 25.0-30.0. Synonym: Coccidium ? sp. Thélohan, 1894 (431); Coccidium théholani Labbé, 1896 (220). In Labrus sp., Wrasse. (Pisces: Percomorphi)

E. thianethi Gwéléssiany, 1935 (162, 163). (M) 42.6 x 28.6. Considered

synonym of E. smithi and E. bukidnonensis by Yakimoff, 1936 (473), but it may be a valid species. In Bos Taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. transcaucasia Yakimoff and Gousseff, 1937 (497). (Provisional species!). (R) 16.0-18.0. (M) 16.5. In Bufo bufo (="B. vulgaris"), a Toad. (Amphibia: Salientia)

E. (Globidium) travassosi (da Cunha and Muniz, 1928 (95)) emend. Reichenow and Carini, 1937 (372). (M) 60.0 x 45.0. Synonym: E. ? travassoi da Cunha and Muniz, 1928 (95). Possible synonym of E. (Globidium) tatusi da Cunha and Torres, 1926 (96). (Cf. Reichenow and Carini, 1937 (372)). (R) 50.0-52.0 x 39.0-40.0. In Dasypus sexcinctus; Muletia hybrida; both Armadillos. (Edentata: Cingulata)

E. triangularis Chakavarty and Kar, 1943 (71). (R) "Triangular in shape, measuring 10.3-14.4 in longest diameter." In Trionyx gangeticus, Ganges Soft-Shelled Turtle. (Reptilia: Chelonia)

E. triffittae (Yakimoff, 1934 (469)) emend. Hardcastle, 1943 (171). (R) 23.5-34.0 x 16.5-20.0. (M) 21.1 x 17.8. Synonym: Eimeria triffitt Yakimoff, 1934 (469). In Taurotragus ("Oreas") canna, Eland. (Artiodactyla: Bovinae)

E. trionyxae Chakravarty and Kar, 1943 (71). (R) 14.4-18.5 x 14.4-18.5. (M) 16.5 x 16.5. In Trionyx gangeticus, Ganges Soft-Shelled Turtle. (Reptilia: Chelonia)

E. tritonis (Labbé, 1896 (220)). Homonym of E. tritonis Steinhaus, 1891 (419). Synonym of E. labbei Hardcastle, 1943 (171).

E. tritonis (Steinhaus, 1891 (419)) Levine and Becker, 1933 (258). Synonym of E. salamandrae (Steinhaus, 1889 (418)).

E. tropidonoti Guyénot, Naville and Ponse, 1922 (161). (R) 22.0-24.0 x 12.0-14.0. In Natrix ("Tropidonotus") natrix, Common Grass Snake. (Reptilia: Serpentes)

E. tropidura Carini, 1941 (55). Synonym of E. stenocerci Carini, 1940 (54).

E. truncata (Railliet and Lucet, 1891 (343)) Wasielewski, 1904 (447). (R) 20.0-22.0 x 13.0-16.0. Synonym: Coccidium truncatum Railliet and Lucet, 1891 (343). In Anser anser anser, Domestic Goose: Anser cinereus, Graylag; Branta canadensis, Canada Goose. (Aves: Anseriformes)

E. truttae (Léger and Hesse, 1919 (244)) Stankovitch, 1924 (417) (R) 10.0-12.0 x 10.0-12.0. Synonym: Goussia truttae Léger and Hesse, 1919 (244). In Salmo fario, a salmon. (Pisces: Isospondyli)

E. tuis. Lapsus for E. suis.

E. tyzzeri Yakimoff and Rastegaieff, 1931 (529). (R) 25.0-37.0 x 18.9-26.6. (M) 31.8 x 23.3. Validity questioned by Hardcastle, 1943 (171). In Gallus domesticus, Common Fowl or Chicken. (Aves: Galliformes)

E. uniungulati Gousseff, 1934 (151). (R) 15.5-24.9 x 12.4-17.0. In Equus caballus, Domestic Horse; also in Ass and Mule. (Perissodactyla: Equidae)

E. uniungulata. Lapsus for E. uniungulati.

E. urnula Hoare, 1933 (184). (R) 17.6-23.2 x 12.8-13.6. Synonym: Eimeria cernula Hoare, 1933 (184), lapsus. In Phalacrocorax carbolugubris, Cormorant. (Aves: Pelecaniformes)

E. ursi Yakimoff and Matschoulsky, 1935 (508). (R) 12.6-14.7 x 10.5-12.6. In Ursus arctos, Brown Bear. (Carnivora: Ursidae)

E. ussuriensis Yakimoff and Springholtz-Schmidt, 1939 (534). (M) Round forms, 22.1; subspherical forms, 22.9 x 20.3; ovoid forms, 22.6 x 19.5; oval forms, 23.4 x 20.0. In Citellus ("Spermophilus") eversmanni, a ground squirrel. (Rodentia: Sciurinae)

? E. utinensis Selan and Vittorio, 1924 (Clin. Vet. Milano 47:587-592). Probably not a coccidium: description inadequate. (Cf. Wenyon, 1926 (450)). In Equus caballus, Domestic Horse. (Perissodactyla: Equidae)

E. variabilis (Thélohan, 1893 (430)) Reichenow, 1921 (370). (R) 15.0-20.0 x 15.0-20.0. Synonyms: Coccodium variabile Thélohan, 1893 (430); Goussia variabilis (Thélohan, 1893 (430)) Labbé, 1896 (220). In Anguilla vulgaris, Eel; Cottus bubalis, European Father-Lasher; Crenilabrus melops, Fournie; Gobius bicolor and Gobius paganellus, gobies; Lepadogaster gouanii, "Pei puorc". (Pisces: various orders)

E. ventriosa Haase, 1939 (164). (R) 31.5-33.5 x 20.4-22.9. In Tetrao urogallus, Heath Cock. (Aves: Galliformes)

E. viridis (Labbé, 1893 (213)) Reichenow, 1921 (370). Synonym: Coccidium viride Labbé, 1893 (213). In Rhinolophus ferrumequinum, Greater Horshoe Bat., (Chritoptera: Rhinolophidae)

E. vison Kingscote, 1935 (203). (R) 17.0-22.1 x 9.0-18.0. (M) 20.3 x 14.6. Synonym: Eimeria mustelae Kingscote, 1934 (202), nec Eimeria mustelae Iwanoff-Gobzem, 1934 (193). In Mustela vison, (North American) Mink; Mustela putorius furo, Ferret. (Carnivora: Mustelinae)

E. volgensis Sassuchin and Rauschenbach, 1932 (384). (R) 23.2-31.9 x 17.4-27.6. (M) 27.2 x 21.9. In Citellus pygmaeus, LIttle Souslik or Steppe Squirrel. (Rodentia: Sciurinae)

E. votti. Lapsus for E. cotti.

E. vulpis Galli-Valerio, 1929 (138). (M) 17.0 x 14.0. In Vulpes vulpes, Common Red Fox (Old World). (Carnivora: Caninae)

E. waltoni Saxe, 1955 (387). (R) 20.0-24.2 x 16.9-20.9. (M) 22.2 x 19.2. In Ambystoma tigrinum, a salamander. (Amphibia: Caudata)

E. wapiti Honess, 1955 (Bull. 8, Wyo. Game and Fish Com. pp.25-28) (R) 32.0-42.3 x 24.0-28.8. (M) 38.2 x 26.3. In Cervus canadensis nelsoni, American Elk or Wapiti. (Artiodactyla: Cervinae)

E. wassilewskyi Rastegaïeff, 1930 (347). (M) 18.0 x 14.4. In Axis ("Cervus") axis, Spotted Deer; Cervus elaphus, Red Deer; Cervus albirostris (= "Pseudaxis dybowskii"), Thorold's Deer. (Artiodactyla: Cervinae)

E. wenyoni Dobell, 1919 (103). Synonym of E. clupearum.

E. wierzejskii Hofer, 1904 (186). (R) 11.0-12.0. (Oocysts found within Myxosporidia.) In Cyprinus carpio, Carp. (Pisces: Ostariophysi)

E. wyomingensis Huizinga and Winger, 1942 (191). (R) 37.0-40.0 x 26.4-30.8. (M) 40.3 x 28.1. Probable synonym of E. bukidnonensis. In Bos taurus, Domestic Cow. (Artiodactyla: Bovinae)

E. yakimoff Rastegaïeff, 1929 (344,348). (R) 32.4-41.4 x 21.6-28.8. In Boselaphus tragocamelus, Nilgai. (Artiodactyla: Bovinae)

E. yakisevi Hardcastle, 1943 (171). (M) 19.5 x 24.4. Synonym: Eimeria brumpti Yakimoff and Gousseff, 1936 (489); non Eimeria brumpti

Cauchemez, 1921 (67). In Dendrocops ("Dryobates") major, Woodpecker; Tetrao urogallus, Heath Cock. (Form in woodpecker has become E. nonbrumpti Levine, 1953). (Aves: Piciformes and Galliformes, resp.)

E. zamensis Phisalix, 1921 (319). (R) 28.0-30.0 x 15.0-18.0. In Coluber ("Zamensis") sp.; Coluber constrictor, Blacksnake; Coluber constrictor flaviventris, Eastern Blue Racer; Masticophis flagellum, Eastern Coachwhip. (Reptilia: Serpentes)

E. zurnabadensis Yakimoff, 1931 (461). Synonym of E. canadensis.

E. zürnii (Rivolta, 1878 (374)) Martin, 1909 (275). (R) 15.0-22.0 x 13.0-18.0. (M) 17.8 x 15.6. Synonyms: Cysospermium zürnii, Rivolta, 1878 (375); Coccidium zürnii (Rivolta, 1878 (375)) Railliet and Lucet, 1891 (343); Coccidium bovis Züblin, 1908 (534), pro parte; Eimeria bovis (Züblin, 1908 (534)) Fiebiger, 1912 (125), pro parte; Eimeria canadensis Bruce, 1921 (28), pro parte. In Bos taurus, Domestic Cow; Bos ("Bibos") indicus, Zebu. (Artiodactyla: Bovinae). In Cervus canadensis, Wapiti, or American Elk. (Artiodactyla: Cervinae). In Rangifer sp., Caribou. (Artiodactyla: Odocoileini)

9. WENYONELLA Hoare, 1933 (184)

Type species: W. africana Hoare, 1933 (183)

W. africana Hoare, 1933 (184) (Type species). (R) 18.5 x 16.0-19.2 x 17.6. In Boaedon ("Boaodon") lineatus, Brown House Snake. (Reptilia: Serpentes)

W. bahli Misra, 1944 (285). (R) 16.0-17.5 x 14.6-15.5. In Coturnix communis, Common Grey Quail (of India). (Aves: Galliformes)

W. gallinae Ray, 1945 (355). (R) 29.5-33.5 x 19.8-22.8. In Gallus domesticus, Common Fowl or Chicken. (Aves: Galliformes)

W. hoarei Ray and Das Gupta, 1937 (359). (R) 14.0-18.5. In Sciurus sp., an Indian Squirrel. (Rodentia: Sciurinae)

W. mackinnoni Misra, 1947 (286). (R) Round forms, 19.0-23.0; ovoid forms, 23.8-26.2 x 18.0-21.5. In Motacilla alba, European White Wagtail. (Aves: Passeriformes)

W. parva Berghe, 1938 (16). (M) 15.2 x 13.3. In Tamiscus ("Paraxerus") anerythrus and Tamiscus emini, African "Bush Squirrels". (Rodentia: Sciurinae)

W. uelensis Berghe, 1938 (16). (R) 26.0-30.0 x 19.0-20.0. In Funisciurus anerythrus, African Tree Squirrel. (Rodentia: Sciurinae)

10. OCTOSPORELLA Ray and Raghavarchari, 1942 (366)

Type species: O. mabuiae Ray and Raghavachari, 1942 (366)
(This genus is placed provisionally in the family Eimeriidae, although the method of formation of male gametes is still unknown.)

O. mabuiae Ray and Raghavachari, 1942 (366). (Type species) (R) 14.0-16.0 x 14.0-16.0. In Mabuya sp., an Indian lizard. (Reptilia: Sauria)

11. YAKIMOVELLA Gousseff, 1937 (153)

Type species: Y. erinacei Gousseff, 1937 (153)

(Objection to the validity of this generic name could be based on the previous appearance, in parenthesis, of the name in connection with another coccidium, in synonymy.) (See Gousseff, 1936, 153).

Y. erinacei Gousseff, 1937 (153). (Type species). In Erinaceus europaeus, Hedgehog. (Insectovora: Erinaceidae)

12. PYTHONELLA Ray and Das Gupta, 1937 (362)

Type species: P. bengalensis Ray and Das Gupta, 1937 (362)

P. bengalensis Ray and Das Gupta, 1937 (362). (R) 25.0-30.0 x 25.0-30.0. In Python sp., a python. (Reptilia: Serpentes)

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